Environmental Library JUN 16 1917 UNIV. OF MICH. LIBRARY

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

VOL. CIII.—No. 2682.] *LONDON: FRIDAY, MAY 25, 1917.* [*Registered at the General Post Office as a Newspaper.*] PRICE...9d. BY INLAND POST...10d.

Aveling & Porter, Ltd.,
ROCHESTER, KENT,
and 72, CANNON STREET, LONDON.
STEAM ROLLERS. ROAD LOCOMOTIVES.
STEAM CULTIVATING MACHINERY.
STEAM WAGONS. TRACTORS
CEMENT-MAKING MACHINERY. 6080

A. G. Mumford Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, page 29.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Cement.—Maxted & Knott,
LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest references. Established 1880.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull." 5304

Cranes.—Electric, Steam,
HYDRAULIC and HAND.
of all types and sizes.
GEORGE RUSSELL & CO., LTD.,
Motherwell, near Glasgow. 5007

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 4457
See Advertisement last week, page 103.

Plenty and Son,
LIMITED.
MARINE ENGINES, &c.
NEWBURY, ENGLAND. 9083

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD.,
ENGINEERS, NEWCASTLE-ON-TYNE. 5099

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON AND TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORKS, also CAST-STEEL AXLE BOXES. 5760

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS,
OF EVERY DESCRIPTION,
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 120, Trongate, GLASGOW. Od 8847
Registered Offices: 109a, Cannon St., London, E.C.

Fuller, Horsey, Sons & Cassell,
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY
and
ENGINEERING WORKS.
11, BILLITER SQUARE, LONDON, E.C. 3 Od 1234

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works, Manchester. Od 9729

Iron and Steel
Tubes and Fittings.
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 35. 5585

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS,
GLASGOW (formerly of POPLAR, LONDON),
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF
Exceptional Shallow Draught.
VESSELS PROPELLED BY STEAM
Turbines or
Internal Combustion Engines. Od 8789

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 18 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches, or Barges,
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 8551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

FOR
Drop Stampings
write
GARTSHERRIE ENGINEERING & FORGE CO.,
50, WELLINGTON STREET, GLASGOW. 5435

Oil Fuel Appliances.
SYSTEMS { PRESSURE. AIR. STEAM.
FOR BOILERS OF ALL TYPES.
Kermodes Limited,
35, THE TEMPLE, DALE STREET, LIVERPOOL;
and
109, FENCHURCH STREET, LONDON. 4078
NAVAL OUTFITS A SPECIALTY.

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Od 2437
See their Illus. Advertisement page 111, last week.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 100, May 18. 5734

Punch and Shear Machine SPECIALISTS. 4784
Consult us. "The Best and the Cheapest." Large Stock. Satisfaction Guaranteed. Established 1860.
SCOTT BROS., WEST MOUNT, HALIFAX.

"Gripoly"
MACHINE BELTING
FOR
Driving
Conveying
Elevating
SOLE MANUFACTURERS
Lewis & Tylor, Ltd.,
CARDIFF. 5484
LONDON. MANCHESTER. GLASGOW.

Experimental and Research
WORK UNDERTAKEN
BY
THE AERONAUTICAL INSTITUTE OF GREAT BRITAIN
at their Experimental Workshop and Industrial Laboratory. 5343
Offices: 3, Arlington Street, St. James's, S.W. Tel: Gerrard, 6468.
Workshop & Laboratory: 45, Horseferry Road, Westminster. Wire: Zepstraffa, London.

John Bellamy, Limited,
MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes, Iron and Steel.
Edwin Lewis & Sons, Ltd.,
Wolverhampton. 5628

Tubes and Fittings.
Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 60. 5701

Rubber MANUFACTURERS
Belting
GUTTA PERCHA & RUBBER, LIMITED
Toronto - - - Canada. 5013

New Chicago Automatics,
Three Sizes, Delivery from Stock.
NEW CAPSTANS, 1¼ in. through the wire feed.
JOHN MACNAB, MARY STREET, HYDE.
Tel. No.: 78 Hyde. 5319

THE WELL-KNOWN
Fine Red Moulding Sand,
FOR
IRON, BRASS, ALUMINIUM.
APPLY,
Mansfield Sand Co., Ltd.,
MANSFIELD, NOTTS. 5175

The Norman Thompson Flight Co., Ltd. (RSTD. 1909.)
CONTRACTORS TO THE ADMIRALTY.
"THE FIRM WHO GAVE THE FLYING BOAT TO THE NAVY."
ALL BRITISH BUILT. 5999
Works:—MIDDLETON, BOGNOR, ENGLAND.
London Office:—DEWAR HOUSE, 11, HAYMARKET.
Telegrams—"Soaring, Bognor." Telephones—Bognor 48.
"Entflyte, Charing, London." Gerrard 7205.

Machine Tools in Stock:—
Vertical DRILLS, to admit 18 in., 26 in., and 36 in. diameter. Bolt Screwing MACHINES. 10½ in. centre Special Shafting LATHE. Second-hand PLANER, 25 ft. by 6 ft. by 6 ft.
JAMES SPENCER & CO., LTD., 4360
Chamber Iron Works, Hollinwood, Manchester.

R. Y. Pickering & Co., Ltd.
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
London Office: 8263
3, VICTORIA STREET, WESTMINSTER, S.W.

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS. 5024
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.
See half-page Advertisement, last and next week.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS,
CONDENSERS, AIR HEATERS,
STEAM AND GAS KETTLES. } Row's Patents
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5733

Yarrow Patent
Water-tube Boilers.
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

RAILWAY CARRIAGES, ELECTRIC CARS, &c.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS,
MOTHERWELL. Od 3000

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, Dumbarton. 5204
See Full Page Advt. page 56, May 4.

Forgings.
Walter Somers & Co., Ltd.,
HALESOWEN. 5549

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 24, May 11. 2403

Taylor & Challen
Presses.
8196

Railway
Switches and
Crossings.
T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 5440

Coke, Gas and Oil Fired
FURNACES 4840
MONOMETER MANUFACTURING CO., LTD.,
ASTON, BIRMINGHAM.
See Advertisement page 86, May 11.

Gas Engines, Suction Plants,
Inspections, Tests and Reports. Expert advice.—R. J. DAVIS, M.I. Mech. E., Great Eastern Road, Stratford. Telephone: East 1360; Stratford 569. Tel.: Rapidising, London. 1704

Aluminium.
INGOTS, BILLETS, SHEET, WIRE, BAR, ROD, TUBE, SECTIONS, POWDER, ALLOYS, &c.
5919
THE BRITISH ALUMINIUM CO., LTD.,
109, Queen Victoria St., E.C. 4.

CHANTIERS & ATELIERS
Augustin - Normand
67, rue de Perrey—LE HAVRE
(France.) 3990
Destroyers, Torpedo Boats, Yachts and Fast Boats.
Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
5466
See half-page Advertisement page 70, May 18.

The Manchester Steam Users' ASSOCIATION.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir W. FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 5884

The Manchester Steam Users' ASSOCIATION.

—The ANNUAL GENERAL MEETING of the Members was held in the Board Room of the Association, at their Offices, 9, Mount Street, Manchester, on Tuesday, 22nd May, HAROLD LEE, Esq. (Manchester), President, in the Chair, when the following resolutions were adopted:—

Moved by the Chairman, seconded by EDWARD HOPKINSON, Esq., D.Sc. (Manchester), and resolved:—

"That the Report of the Committee of Management to the Subscribers be adopted."

Moved by F. G. BROADHEAD, Esq. (Messrs. Richard Silcock & Sons, Ltd., Liverpool), seconded by J. G. THOMPSON, Esq.) The Collins Green Colliery Co., Ltd., St. Helens), and resolved:

"That the thanks of the Association are due, and are hereby presented to the Committee of Management for their past services, and that the following gentlemen be elected the Committee for the ensuing year, with power to add to their number:—

COMMITTEE OF MANAGEMENT:
HAROLD LEE, Esq., Manchester.
CHARLES HEATON, Esq., Bolton.
EDWARD HOPKINSON, Esq., D.Sc., M.Inst.C.E., M.I.Mech.E., Manchester.
HENRY WHITEHEAD, Esq., M.V.O., Bury.
The Hon. EDWARD COZENS-HARDY, St. Helens.
A. NORMAN DUGDALE, Esq., Blackburn.

Moved by EDWARD PEERS, Esq. (Messrs. Robert Peers, Ltd., Bury), seconded by G. E. RIDYARD, Esq. (Messrs. William Ramsden & Sons, Ltd., Tyldesley) and resolved:—

"That Messrs. F. W. POPPLEWELL & SON, Chartered Accountants, Manchester, be appointed Auditors of the Association's accounts for 1917, at the same remuneration as before."

EDWARD A. BATEMAN, Secretary.
9, Mount Street, Albert Square, Manchester.
23rd May, 1917. G 867

TENDERS.

GLAMORGAN COUNTY ASYLUM.

TO ENGINEERS.

The Committee of Visitors of the Glamorgan County Asylum invite

Tenders for the Heating of

FEMALE WARD IV at Angelton Asylum, Bridgend, Glamorgan.

Further particulars may be obtained from the undersigned, and sealed Tenders (which must be on the Form supplied), addressed to me, marked outside "Tender for Heating Female Ward IV at Angelton," must be received not later than Ten a.m. Wednesday, the 13th day of June, 1917.

The person or firm whose Tender is accepted must produce evidence of being insured against liability for accidents to workmen, and will be required to enter into an approved Contract for carrying out the work and give approved security for due performance thereof.

The Committee will not necessarily accept the lowest or any Tender.

(Signed) W. E. R. ALLEN,
Clerk of the Committee of Visitors.
Glamorgan County Hall, Cardiff,
23rd May, 1917. G 873

IN THE MATTER OF THE TRADING WITH THE ENEMY AMENDMENT ACT, 1916.

The PUBLIC TRUSTEE invites

Tenders for the Purchase of

the Whole or any part of 119,660 Shares of £5 each, fully paid, in SIMMINS BROTHERS & COMPANY, LIMITED, vested in him as Custodian by an Order made by the Board of Trade, in pursuance of Section 4 of the Trading with the Enemy Amendment Act, 1916, and dated 9th August, 1916.

The issued capital of the Company consists of 120,000 Shares of £5 each, fully paid.

The purchasers, who must be British-born subjects, will be required to make a sworn Declaration as to nationality and freedom from foreign control on a form to be obtained from the Offices of the Public Trustee.

The purchasers will also be required to satisfy the Public Trustee as to their financial and technical ability to carry on the business of the Company as efficiently as heretofore, or otherwise to the satisfaction of the Government.

A report upon the Company's operations and affairs has been prepared by the Company, in conjunction with the Company's Auditors (Messrs. PRICE, WATERHOUSE & Co.), and with Messrs. TURQUAND, YOUNGS & Co. Copies of this report can be obtained, subject as hereinafter mentioned, together with copies of Company's accounts up to the 31st December, 1916, on written application to the Public Trustee, Kingsway, W.C.

All applicants will be required to satisfy the Public Trustee as to any matter which he may think fit to investigate before copies of such Report or accounts will be supplied.

Intending Tenderers who desire to inspect the property of the Company, should apply to the Public Trustee for an authority to do so.

Tenders must be delivered, sealed, to the Public Trustee, Kingsway, W.C., on or before Thursday, the 14th June, 1917 (NOT APRIL 2ND, AS PREVIOUSLY ADVERTISED), at Twelve o'clock Noon, and marked on the envelope, "Tender, Siemens Shares."

The Public Trustee does not bind himself to accept any Tender, and reserves to himself all rights in connection therewith.

Forms of Tender can be obtained from the PUBLIC TRUSTEE.

Dated this 8th day of February, 1917. 5942
C. J. STEWART, Public Trustee,
Custodian for England and Wales.

APPOINTMENTS OPEN.

Senior Assistant Chemist

REQUIRED, experienced in iron, steel, non-ferrous metals, refractories, &c. State age, experience and salary required.—Address, G 849, Offices of ENGINEERING.

RUTHERFORD TECHNICAL COLLEGE, NEWCASTLE-UPON-TYNE.

Principal—
C. L. ECLAIR-HEATH, Wh.Sc., A.M.I.M.E.

APPOINTMENT OF LECTURER IN ENGINEERING.

The Council of the College invite

Applications for the above

APPOINTMENT from Gentlemen ineligible for, or exempted from, military service and having college training and good experience in works, drawing offices, and engineering laboratories. Preference will be given to candidates having experience in modern marine engineering practice. The appointment is for the duration of the war, and the salary is £250 to £300 per annum, according to qualification and experience.

Applications must be made on forms to be obtained from the undersigned, from whom further particulars may be obtained, on receipt of a stamped, addressed, foolscap envelope.

Applications must be sent in not later than 2nd June, 1917.

PERCIVAL SHARP,
Director of Education.

Education Offices,
Newcastle-upon-Tyne. G 797

STANLEY JUNIOR TECHNICAL SCHOOL, SOUTH NORWOOD HILL, S.E. 25.

The Board of Governors require immediately the

Services of Two Assistant

MASTERS for the Permanent Staff.

(A) Master specially qualified to give instruction in Geometrical Drawing and Drawing Office Practice.

(B) Master specially qualified to give instruction in English Subjects and Geography.

Commencing salaries £130 to £175 according to qualifications and experience.

Candidates must be ineligible for military service.

Terms of appointment and form of application, which should be sent in as soon as possible, may be had on application to the undersigned.

I. W. RICHARDSON,
Headmaster. G 823

SUPERINTENDENT RATE FIXER.

There is a Vacancy in a Large

Aeroplane Factory, London, N.W., for a man to take charge of rate fixing department for construction of metal aeroplane components.

For a really capable man there would be adequate remuneration and excellent prospects.

No one already engaged on Government work or living more than ten miles away need apply.

Write, 1857, SELL'S Advertising Offices, Fleet Street, E.C. 4.

G 782

Works Accountant Required

by large Government-controlled Engineering Works in Manchester district, making large and small engines, repetition and general work. Applicants must have had first-class experience in Factory Accounting, and be capable of developing thoroughly modern system of cost and expense records; one accustomed to Hollereth Tabulating Machine preferred.—Apply, stating age, details of experience and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting this Journal and No. A 3182. No person on Government work will be engaged. G 706

Required, Manager for Steel

Foundry in South of England. Must have good knowledge of chemistry, and be thoroughly conversant with latest foundry practice. Liberal salary to first-class man.—Write BOX 8463, care of A. J. WILSON & Co., LTD., 154, Clerkenwell Road, London, E.C. 1. G 768

Iron and Steel Works Engineer.—WANTED,

by the CONSETT IRON CO., Ltd., a thoroughly qualified MECHANICAL ENGINEER, for its iron and steel works. He must be fully competent and have had experience in a similar situation. The position is one of importance, and a liberal salary will be paid to a suitable man.—Applications, stating qualifications, age, experience and salary expected, together with copies of testimonials, to be addressed to G. AINSWORTH, General Manager, Consett Iron Co., Ltd., Consett, Co. Durham. G 853

Wanted, Able Engineer, with

experience of works management and design, for Responsible Position, with general supervision of two works at present on war work, engaged after the war on variety of special light engineering work.—Address, G 833, Offices of ENGINEERING.

Estimating Clerk Wanted,

for large works in the Midlands, producing Wrought and Cast Ironwork. Permanent situation. Practical works knowledge and previous experience in costing essential. No person already on Government work will be engaged.—Apply, stating full particulars and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3238. G 848

Cost Clerk Required for

large Engineering Works. No one engaged on Government work or resident more than 10 miles away will be engaged.—Apply, stating age, experience and salary required to WORKS ACCOUNTANT, VICKERS LIMITED, Crayford. G 754

Assistant Electrical Engineer

REQUIRED in connection with running and developing a large 3-phase Colliery Plant in China. Free quarters provided, and free passage out and home. Three years' agreement. State age, salary expected, and full particulars and references. —Apply, ARTHUR HASSAM, Consulting Engineer, Newcastle, Staffs. G 843

Inspector Wanted, for Tool

room of an important company engaged on war munitions, to inspect small tools, cutters, gauges, &c. Must be a first-class man with initiative. No person already on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, quoting No. A 3230. G 838

Wanted to Travel, Expert

ENGINEERS' TOOL-HARDENER. Experienced toolmaker preferred, capable of demonstrating heat treatment of special alloy steels. Salary £5 weekly and expenses. No one already on Government work can be engaged.—Write, 25, SELL'S Advertising Offices, Fleet St., E.C. 4. G 811

Buyer Wanted, by large

engineering firm in Midlands, to take entire charge of purchases department. Thorough knowledge of wrought iron, steel, and pig iron essential. —Address, stating full particulars and salary required, G 875, Offices of ENGINEERING.

Wanted, for Controlled

Establishment in Glasgow, EXPERIENCED MAN, well versed in operations on small engine work, and able to design jigs for same. Good salary to suitable party. No one employed on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 868.

Wanted, Draughtsman for

the mechanical design of large electrical direct current machines. Nobody engaged on Government work will be accepted.—Write or apply to the nearest Board of Trade EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 2631. G 457

Wanted, Immediately, Thor-

oughly Experienced MECHANICAL DRAUGHTSMAN; experienced in electrical plant an advantage but not essential.—Applications, which should give full details of previous experience and salary required, should be made to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3184. No person already engaged on Government work will be engaged. G 721

Experienced Ship and Pipe

arrangement DRAUGHTSMAN WANTED, for controlled marine engine works on N.E. coast. State age, experience, and salary desired. Permanency to good man. No one already engaged on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 780.

Wanted, Good Mechanical

DRAUGHTSMEN. Aeroplane experience preferred, but not necessary.—Apply, by letter, stating experience and salary required, to S.D.O., Air Board Office, Strand, London, W.C. 2. G 852

Jig and Tool Draughtsman

REQUIRED in aeroplane factory, London, N.W. Good prospects for a live man. No one already engaged on Government work or resident more than 10 miles away need apply.—Write, 1856, SELL'S Advertising Offices, Fleet St., E.C. 4. G 781

Wanted, Chief Draughtsman

for Machine Tool Works employing about 120 hands. No one already employed on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 846.

Wanted (for Yorkshire),

DRAUGHTSMAN, for shell forge, press tools, lay-outs, &c. No one engaged on Government work will be engaged.—Apply, nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 865

Jig and Tool Draughtsman

WANTED AT ONCE, for a Controlled Establishment, manufacturing Aeroplanes. Progressive position for a real live man. No one already employed on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 845.

Good Mechanical Draughts-

MAN WANTED, for Admiralty establishment, accustomed to small high-class work preferred.—Apply (by letter only), stating age and present salary, to BOX No. 1094, care of Messrs. R. F. WHITE & SON, Gen. Advng. Agents, 33, Fleet Street, E.C. 4. G 833

Draughtsman Required, for

Controlled Blast Furnaces and Rolling Mills on the North-East Coast.—Apply your nearest EMPLOYMENT EXCHANGE, stating age, experience, and salary required, quoting No. A 3237. Men already on Government work need not apply. G 857

Expert Draughtsman Wanted

in large London drawing office, with thorough knowledge of internal combustion or steam engines. —Write, stating experience, salary required, and when free, to BOX No. 1107, care of R. F. WHITE AND SON, Genl. Advng. Agents, 33, Fleet Street, E.C. 4. G 861

Large Engineering Firm in

Manchester district REQUIRES Architects' DRAUGHTSMAN, in connection with re-organisation and erection of new buildings. Applicant must have had previous experience in engineering steel works or colliery plants. State salary required. No person already employed on Government work need apply.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3219. G 784

Draughtsman, Junior

MECHANICAL, WANTED, by Midland firm manufacturing Ball and Roller Bearings for Aircraft and Mechanical Transport. Good salary according to experience. No man already on Government work can be engaged without consent of present employers.—Application in the first instance should be made to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 3234. G 843

Wanted, by Railway Com-

pany in London, DRAUGHTSMAN (ineligible) with experience of Railway Electric Signalling.—Address, G 827, Offices of ENGINEERING.

Wanted, Experienced Lady

TRACERS, accustomed to small high-class Engineering work. State age, experience, and present salary; also enclose recent sample of work. —Apply (by letter only), BOX No. 1102, care of Messrs. R. F. WHITE & SON, Genl. Advng. Agents, 33, Fleet Street, E.C. 4. G 859

Wanted, Foreman over 50

Machines and Lathes, large and medium; capable of getting maximum output. State age, present and previous employers, and wages. No man on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 656

Wanted (for Yorkshire),

NIGHT FOREMAN, used to operation and maintenance Gas Producers and Gas Shell Furnaces (preferably Wincott's). No one employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and G 864.

Junior Assistant Wanted, by

Manager of Inspection Department in munition factory. Must be skilled engineer, preferably with drawing office experience. No person already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, quoting No. A 3233 G 837

A Large Firm of Engineers,

in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4350, Offices of ENGINEERING.

SITUATIONS WANTED.

Works Manager, Technical

and Commercial, 44, DESIRES POSITION. 25 years' experience in high-class Steel Foundries and Steel Works engaged on all classes of material. —Address, G 760, Offices of ENGINEERING.

Works Manager (40).

Technical, commercial and thoroughly practical engineer, wide experience of works organisation and administration, rapid and economical production of high-class, interchangeable, competitive repetition work, munitions, motor and general engineering. Maximum output from labour and machines. Has held position of general manager for past 12 years with up-to-date progressive firm.—Address, G 855, Offices of ENGINEERING.

Works Engineer (46),

M.I.Mech.E. Thorough practical man. Mechanical electrical, hydraulic, refrigeration, gas, regenerative furnaces, power gas, general building. All classes of work. Accustomed control of men, all departments. Some experience coal tar products distillation. DESIRES permanent POST as Chief Engineer or Master of Works.—Address, G 874, Offices of ENGINEERING.

Mechanical Engineer (33)

REQUIRES responsible POSITION. Thorough practical and theoretical knowledge in general engineering, extensive experience in lifting and ships auxiliary machinery. Costing, estimating and drawing office. Salary about £450.—Address, G 759, Offices of ENGINEERING.

Energetic Young Russian

Engineer and Architect, who speaks English, with excellent references (premiums), and 10 years' experience in building factories, WANTS a high PLACE in an English firm in Russia.—Please write to Voronezh, Russia, Bolshaja Moskowskaya 21, Mr. M. OZMIDOFF. G 808

Steel Works Cashier and

Costs Superintendent, would take up similar POSITION; 43. Thoroughly conversant with basic open hearth furnace costs, and general office procedure.—Address, G 829, Offices of ENGINEERING.

Swiss Technical Draughtsman

with practical and theoretical experience in locomotive and combustion engine and general machinery, SEEKS POSITION.—Address, G 830, Offices of ENGINEERING.

Foundry Manager, Iron and

Brass, DESIRES POSITION in marine or general engine works. Six years as foundry manager with a large firm of marine and turbine engineers, with records to prove good results. First-class organiser and metallurgist and a practical moulder. Can produce sound clean castings up to 30 tons in weight. Loam and dry sand. Green sand. Repetition work with machine and plate. Age 40. Replies treated in confidence.
Address, G 858, Offices of ENGINEERING.

Wanted Post as Foreman

Millwright and Fitting Shop Foreman. Age 45. Accustomed to up-to-date workshop practice and controlling both skilled and unskilled labour. Six o'clock man.—G 870, Offices of ENGINEERING.

PARTNERSHIPS.

Partners
Directors
Businesses
Factories

for these apply to

WHEATLEY KIRK, PRICE & CO.,
46, Watling Street, LONDON, E.C.
Albert Square, Manchester.
20, Collingwood Street, Newcastle-on-Tyne. 5705

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE last meeting of the 1916–17 session of the Institution of Mechanical Engineers was held at the Institution of Civil Engineers on Friday last, the 18th inst., Mr. Michael Longridge, president, in the chair. The minutes of the previous meeting having been read and confirmed, the list giving the results of the ballot for the election of 95 new members was also read.

NOTES ON THE CONSTRUCTION OF TURBINE PUMPS.

A paper bearing the above title was then read by the author, Mr. Alan E. L. Chorlton, of Lincoln. Of this paper we commence the publication in full on page 508 of the present issue. Mr. Chorlton, after reading his paper, said he had not dealt with any very theoretical subject in connection with the normal design of turbine pumps, and he hoped that some of the members present would deal in the course of the discussion with that side of the subject. The turbine pump had attained a certain efficiency, which was pretty well known, but it was a good many per cent. less than that of the water turbine, and it ought to be the object of all turbine pump manufacturers to raise the efficiency as near as possible to that of the water turbine. General practice proved that the turbine pump was gradually driving out of the field all the other types of pumps. He also desired to refer to the necessity of research being carried out in connection with turbine pumps. At the present day there was a large number of bodies and institutions in existence for the purpose of carrying out research; in fact, their number was legion. It seemed to him that the turbine pump ought to be the subject of special research just as much as the internal combustion engine. If the efficiency of such pumps could be raised by even 5 per cent. or 8 per cent. it would be of enormous value represented in pounds, shillings and pence. He desired to say, in conclusion, that he had received considerable help in the writing of the paper from Mr. Owen Price. Owing to pressure of work he had experienced the greatest difficulty in finding time to write the paper, and if it lacked anything he hoped he would be excused.

The president proposed a vote of thanks to the author. The paper was one of a kind that he was particularly anxious to see given more often to the Institution, as it described the results of perseverance in overcoming practical difficulties. He thought it formed a very fitting supplement to Dr. Unwin's classic paper, which had been referred to by the author. The paper also contained a warning to students who had come fresh from college feeling in their own minds their strength and ability to solve all sorts of problems from the knowledge they had gained at college. If they relied solely on that knowledge they would probably come to unutterable grief, not because the knowledge and the formulæ were wrong, but because students could not, with the present mathematical tools available, take account of all the conditions which arose in a practical problem. Having said so much in favour of the paper, he desired to act the part of a candid friend and say he regretted that instead of the diagrams which were given in the paper the author had not given drawings. Whether this was due to want of time for preparing drawings, or from the feeling of secrecy which undoubtedly prevailed among engineers in the present day and the fear of indicating to outsiders the knowledge they had themselves attained with a great deal of trouble, he did not know. It was a very natural feeling, but he did not think it was one that was of benefit to British engineering, and he hoped the time was coming when that kind of secrecy would cease to be considered necessary.

Professor E. G. Coker, D.Sc., F.R.S., after congratulating the author on his very admirable paper, said he desired to ask two questions, the first of which related to Fig. 5 (see page 510). Reference was made by the author to Professor Gibson's conclusions in regard to the best angle of wall diversion, and Fig. 5 showed two guide passages and the lines tangent to them. He desired to ask the author how he selected the point to which he drew the tangent to get that angle, because he had been rather puzzled by the figure in that respect, and probably other members had been puzzled also. The second question he wished to ask had reference to the statement made by the author with regard to the best efficiencies which had been obtained with a turbine pump. If it was not secret he would be glad if the author could furnish figures of the efficiencies which had been obtained in the latest practice in turbine pumps for different powers and different heads.

Mr. T. Y. Sherwell said he was afraid he could not add very much to the statements made in the paper, because although the paper dealt with a type of pump with which he had been associated for many years, the subject had been exhaustively dealt with by the author. He desired, however, to support the author's appeal that further research work should be carried out with the object of improving the efficiency of centrifugal or turbine pumps. Efficiencies as high as possibly 85 per cent. had been secured on representative pumps, but there was no reason why on the larger sizes, with greater quantities of water, the commercial efficiencies obtained should not approach 90 per cent. He felt there was room for independent researches carried out on the lines of Dr. Gibson's work, to which reference was made in the paper. He thought a great deal too much was made of the difference between the two types of casing, the ring casing and the cylindrical casing. In his own experience there had never been any trouble with either the one or the other, although arguments were frequently heard against both types.

Mr. H. Munro, referring to the efficiency aimed at in centrifugal pumps, desired to ask the author for how long such efficiency was maintained. In reciprocating pumps he understood the efficiency was maintained almost indefinitely, but in centrifugal pumps, especially when used with acid or gritty waters, the tips of the propellers wore and the efficiency rapidly fell off. He would be glad if the author could give some figures as to the length of life of the propellers and the time over which the highest efficiency lasted.

Mr. Percy Griffith said he had had some experience in designing pumps to work in bore-holes as distinct from wells. The experience thus obtained had been varied, and that while personally he had not had experience with turbine pumps, he had seen a turbine pump applied to a bore-hole, and he had heard from the gentleman who was using it that it was successful. He asked what the author's recent experience was in regard to applying turbine pumps to bore-holes which involved their being suspended with a vertical shaft operated from the surface, and also the limit of depth to which such pumps could be usefully applied.

Mr. Druitt Halpin referred to a turbine pump, which unfortunately was made in Germany, and was working on a large station—he did not know whether it was a dock or a railway station—in connection with a number of cranes. He presumed it was only being tried tentatively, because a moderate pressure of only about 450 lb. was used, roughly about half of what was used in such work in this country. It seemed an exceedingly simple arrangement and capable of further development. The drawings and a very full description were given in a German paper published in 1913.

Professor P. M. Baker said that he had some tests made a year or two ago on a turbine pump in India, of German manufacture. The manufacturers definitely stated that the efficiency was 70 per cent. to 75 per cent., but the best figure for the actual efficiency obtained on the test was about 56 per cent. to 57 per cent. He desired to ask the author whether there was any reason for supposing that in acid and gritty waters, with which they were much troubled in India, difficulties would arise from electrolytic effects due to the phosphor-bronze impellers being more or less in contact with the cast-iron speed rings and so forth.

The president remarked that no reference was made in the paper to the question of couplings, which were a very important part of the centrifugal pump. It would be of great interest if any of the members could state the right kind of coupling that should be used with turbine pumps.

Mr. Mark Robinson (vice-president) thought it would be of much interest if Mr. Griffith would state what steps were taken to prevent the casing revolving with the turbine pump which was installed in a bore-hole, to which he had referred. Did the bore-hole tube itself act as the delivery pipe, or was there a separate delivery pipe inside the bore-hole? It would also be of interest to know what the diameter of the bore-hole was. [In reply Mr. Griffith stated that he regretted he could not answer Mr. Robinson's questions off-hand, but added that he would be pleased to show Mr. Robinson particulars of the plant if desired.]

Mr. Robert Thomlison said that, as a question had been raised with regard to the pumping of water out of bore-holes, he thought it would be of interest if he stated that in the north country three or four years ago a pit was pumped out with a turbine pump made by Mather and Platt. It took over three years to pump the pit out. The pump was suspended on two cables, and an electric cable was run down to the pump so that it was run by electricity.

Mr. A. J. Bremner remarked, in reply to the president's request for information in connection with couplings, that while he had not designed a turbine pump, he had handled several of them fitted with different kinds of couplings, varying from an ordinary solid flange coupling to a Hooke joint. In most cases it was certainly better to use a flexible coupling, but it was essential to see that the coupling was properly balanced. He had known the outside bearings of the pumps to be ruined in a very short time, entirely due to the fact that the coupling was out of balance.

Mr. G. W. Thompson asked, in connection with Fig. 19, relating to the "Hydraulic Axial Balancing Device" for hydraulic pressure, whether the author recommended any particular pressure. In reply, Mr. Chorlton said it referred to the head water of the turbine discharging into the tail race of the turbine.

Capt. H. Riall Sankey, C.B., R.E., who spoke next, desired to ask the author whether any steps were taken in the works to balance the rotors against dynamic want of balance in the same way in which the rotors of steam turbines were balanced. There were many ways of doing this, and he would like to know whether that was done in the case of very long shafts with very heavy discs. It seemed to him that was just the class of work which required that kind of balance. It also seemed to him that the title of the paper should not be "Notes on the Construction of Turbine Pumps," but "Notes on the Design of Turbine Pumps." The title of the paper might be improved if it could be modified in that way, because very little was said in it about the construction of turbine pumps in the ordinary way.

Mr. A. E. L. Chorlton, in reply, said he very much appreciated the kind manner in which the members had discussed the paper. They had not dealt with it in the aggressive way in which it would have been dealt with in the north of England, for instance. People were much kinder in the south. The president had asked why the sketches in the paper were not made more in the form of working drawings or dimension drawings. He quite agreed with the president's point of view in that respect. He thought it was to be regretted that such drawings were not published. Manufacturers, however, were always apparently afraid of giving their experience away. In the present instance he did not think he quite fell within that category, because he was not now engaged in manufacturing turbine pumps, so that he was not afraid of giving anything away. With the present shortage of draughtsmen, however, it was impossible to get the drawings made. He quite agreed with the president that engineers ought to keep less back in that respect than there was a tendency to do at the present time. Personally he did not think engineers lost by telling all they knew. He quite admitted, in reply to Professor Coker's criticism, that Fig. 5 was a very poor one. Although the diverging angle was supposed to be tangent in both cases to the curves, it did not look from the figure the right way to express it, and he was not positive it was correct. With the

permission of the president he would like to check that figure again; at any rate, he agreed it did not illustrate properly the diverging angle. Then Professor Coker had asked for the efficiencies of turbine pumps. He thought it would have been more fitting if some of the representatives of firms who were making turbine pumps at present had replied to Professor Coker's request for information in regard to the efficiency of such pumps. The variation in efficiency was partly dependent upon the size. At the present day a 500-gallon turbine-pump would have an efficiency of about 76 per cent., while a water turbine under the same conditions would have an efficiency of possibly 84 per cent.—8 per cent. more—or it might be even greater. It was contended as a rule that the reason the one was better than the other was that with a water turbine there was a convergent flow, and with a turbine pump a divergent flow, the one producing eddies and the other suppressing them, but he did not think that ought to be taken altogether as gospel. The efficiencies of turbine pumps had been greatly increased during his time, and he was convinced that by detailed investigation they would be increased still further. He wished that Mr. Sherwell had spoken at greater length, because he had a very wide experience of the subject. In reply to Mr. Munro he desired to say that the maintenance of the efficiency of a turbine pump was a very variable factor. It was obvious that if a well-constructed pump had to deal with perfectly clear water and was only reasonably attended to, it should not wear. In other words, pumps dealing with waterworks water ran for years without being touched. But as soon as that condition was departed from increased possibilities of trouble existed. If a turbine pump was used to pump gritty water, wear would very quickly take place. Many engineers had ceased trying to pump the water that they used to pump in olden days direct through the pump, and had provided a sufficiently large reservoir or settling-pond in front of the pump in order to give it a chance. But even under those conditions the results varied. In one pond the sediment settled so thoroughly that very little wear occurred in the pump.

Whether the art of designing turbine pumps had now arrived at such a fine state of development that it was possible to apportion the right amount of importance to each individual part of the design he did not quite know, but he had tried to point out in the paper one important thing that he thought should be done, *i.e.*, that the shaft stiffness should be increased. By that means it was possible to get fine running clearances; and if that was the case no water passed through, with the result that there was no wear, the object which engineers had in view. He believed in many designs of pump too much was allowed for the intermediate neck rings to carry, and if they had been dispensed with entirely, so to speak, and the shaft had been made stiff, the difficulty would have been got over. If the designs of steam turbines for a few years ago were looked at, it would be found that since that time the shafts had increased enormously. He remembered that in the early days it was not at all an unusual thing for a steam turbine to seize up, due to want of shaft stiffness, and he was inclined to think that progress in regard to turbine pumps ought to be made in a similar direction. Mr. Sherwell might have informed Mr. Munro how the efficiency of the pumps in the Montreal waterworks was maintained as regards wear and tear, due to the fact that they were pumping clean water only.

Mr. Griffith had asked a question connected with the use of turbine pumps in bore-holes. The second turbine pump with which he (the author) had anything to do was put down in a bore-hole in Moscow 18 years ago, and it ran very well. It was an 8-chamber pump, which was entirely suspended from the rising main within the bore casing. It was an ordinary bore-hole lined with a tube of between 18 in. and 24 in. diameter. As it was a long time ago the pump was a fairly big one, but a smaller size could be put in now. The shaft running down the cast-iron rising main was supported at the joints. The pump was an old Reynolds pump. Originally the trouble was not with the pump, but with the ordinary bevel gearing that was fitted at the top to drive from the steam engine. The pump ran for years, but eventually, as no water could be brought up the main, it was taken out. It was drawn up pipe by pipe, and it was then found that the shaft had rusted through in one place, so that the pump had stopped. When a new shaft was put in it ran all right. Though it was possible at the present time to get much smaller pumps, it was necessary to be careful in installing pumps in bore-holes, so that a lot of sand was not disturbed in the first instance.

In reply to Mr. Halpin's remarks and question, Mr. Chorlton desired to say that the highest pressure used in his day was something over 1,000 lb. per sq. in., the pumps running quite well at that pressure. It was then the intention to instal them on battleships for all the high-pressure turret work, because they were self-regulating. It was possible to shut off the main and for nothing to occur. The pumps were electrically driven and it was not necessary for steam pipes to be taken down. The present hydraulic engines were in the ship's bottom and the steam pipes had to go down to them. Thus the pumps to which he had referred offered many advantages, and possibly they might now be used for the purpose he had indicated, although he did not know. He did not think there was any difficulty about using them for any pressure up to about 1,500 lb. Two of the speakers had referred to the efficiency of German pumps. There were very good makers both in Germany and Switzerland, and there was no doubt that with some of the better designs good results were obtained. With a pump of 1,000 gallons or more, 80 per cent. efficiency ought to be approached. The maintaining of the efficiency was simply a question of keeping the water clean. Professor Baker had asked whether electrolysis occurred through the presence of acid water. It was very difficult to say. Personally he did not know that there was electrolysis, and he was not prepared to say, without reference to his old notes, what the proportion of deterioration due to any cause was likely to be. When gritty water was present it was always advisable to put a settling-tank down in front of the pump to clear the water before pumping.

Mr. Robinson had referred to the question of using turbine pumps in bore-holes. He did not remember the smallest bore-hore that turbine pumps had been put into, but he thought the outside diameter of a 500-gallon pump was, speaking from memory, 23 in. With a standard type of pump in a bore-hole an output might be obtained of nearly 1,000 gallons a minute, which was very high for a bore-hole of that size. It was possible to go down to 15 in.

The question of couplings for driving turbine pumps was a very interesting one, and, although he had not mentioned it in the paper, he had thought of it. In the early days of turbine pumps flexible couplings were used, and it was generally thought that they were something that ran out of line; but as time went on he came to the conclusion that flexible couplings did not run out of line any more than solid couplings. They tended, however, to produce a side drag on the bearings, whatever was done, and wearing took place due to the side action of one being one of line with the other. Difficulties might also have occurred due to balance. In the type of flexible coupling then used, which was a sort of interlaced belt, it was very likely found impossible to lace it up evenly, an uneven drive being obtained which had the effect of pushing one shaft out of the straight. At the present time the best coupling was a coupling which was almost equivalent to a solid coupling, except that the connecting bolts had hard rubber sleeves, which acted as a sort of vibration damper. It also allowed for minute out-of-line effect, but it was better that both the motor and the pump should remain in line.

The last speaker, Captain Sankey, had referred to the question of dynamic balancing. Personally he held the view years ago—although he did not know that he held it at present—that it was absolutely necessary to use dynamic balancing, and a machine to secure that object was obtained. It was a machine of very limited capacity; it was not equal to taking the larger discs, although no doubt one could have been constructed. Its application, therefore, was rather limited in the first instance. But there was something else besides dynamic balancing that always used to bother him. For instance, one might say that he would balance on the dynamic machine up to speed; but what was to be done if by any chance, the wheels being cast, the discharge from the periphery was variable, more in one place than in another Captain Sankey might say that that did not wipe out the argument that the other thing was wrong; but nevertheless the fact remained that with dynamic balancing a certain amount of expense was involved, and the engineer began to wonder whether it was worth while when the other condition had to be taken into account. The balancing machine was kept for a considerable time, but in the end it was found hardly worth while to continue with it. He believed the general practice in workshops was not to balance dynamically, but simply to balance individually, or probably collectively, and not to do anything further. He did not think that the whirling speed was high enough to give trouble; it was generally below the critical speed. It was also below the worst effects of out of balance due to the impellers themselves. In the last place, Captain Sankey had criticised the title of the paper. It was always a difficult thing for an author to find a title for his paper, although sometimes he composed a much better title than paper. In the present case he hoped those conditions were reversed. If he had used the word "Design," as Captain Sankey had suggested, there would have been no excuse for him not beginning at the beginning and dealing with the question of how to design an impeller, why he would design it in that way, where the variations would be, why the angle of entrance should be this or that, and so on. He considered that as being the principal basis of the design, and in a way he had not dealt with it, although he agreed that it ought to be dealt with in a very open paper which everybody could criticise. At the same time he agreed that it might have been better to have given the paper another title.

The president said that if the author and Mr. Sherwell, both of whom had referred to the advisability of research being made into the question of centrifugal pumps, had consulted the Journal of the Institution for the past month they would have seen that the council had asked for suggestions for researches, to carry out which Mr. Williamson had given the Institution 500*l*. If any member desired to have a research made into a particular subject, all he had to do was to send notice of the fact to the council before September, and the suggestion would receive very careful consideration.

Before the meeting terminated he asked the members to pass a cordial vote of thanks to the Institution of Civil Engineers for lending their rooms to the Institution for the purpose of holding their meetings, and also for the hospitality that had been extended to them. The resolution of thanks was carried by acclamation. The meeting then terminated.

THE ROYAL VISIT TO MUNITION FACTORIES.

LAST week the King and Queen spent a strenuous time visiting engineering factories each day from morning to night, in one of the busiest industrial areas in the United Kingdom, stretching from Chester to Carlisle and embracing the whole of the north-west of England. Amongst the works visited were the important establishments of Messrs. Cammell Laird and Co., Limited, Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, Manchester; the British Westinghouse and Manufacturing Company, Manchester; the National Projectile Factories and the National Shell Filling Factories in Lancashire; the naval construction works of Messrs. Vickers, Limited; various iron and steel works; and, finally, the New National Factory near Carlisle. At these and other well-known works the King and Queen could not fail to be impressed not only with the proof afforded of the enterprise of our great engineering firms and of the immense capital involved in supplying the necessary munitions of war to our forces, but also with the enthusiasm and loyalty of the great

majority of workers engaged in these establishments.

It would be to the benefit of the people of this country and of our Allies if there could be afforded to them the same demonstration of the immense services rendered by these factories to the world's fight for freedom as was made to the King and Queen, because the part played by the great engineering firms and their great army of industrial workers, particularly women, is only understood in a vague and inconclusive way. We are enabled this week to reproduce some photographs of some departments of these national and privately-owned establishments which were visited by the King and Queen, and to give some suggestion of the immense rapidity with which these factories have been brought into being, of the admirable character of their equipment and of the ingenuity exercised in adapting mechanical devices so as to economise man-power by utilising unskilled labour and the services of women. In some of the works, it is true, there was evidence of the influence of agitators on men who have perhaps been a little overstressed physically owing to the long and uninterrupted labour involved in the maintenance of the flow of munitions to the front; but, as was so admirably expressed in a telegram Mr. Albert Vickers sent after a meeting with the workpeople at Barrow:—

"The presence of the King amongst the people will stimulate and encourage them in their efforts to continue in assisting our brave and gallant sailors and soldiers who are giving their all for freedom and an honourable and permanent peace. As one of the workers said, 'your presence among your subjects as you came to-day must tend to deepen in all your people their determination to achieve a great victory.'"

That His Majesty took this view was shown by his reply to Mr. Albert Vickers, in which he said:—

"I shall indeed be happy if the outcome of our visit to Lancaster and Barrow results in further efforts on the part of those employed in these important works to increase the fighting value of my navy and army. I am confident that British workmen will never fail their fellow countrymen who are fighting our battles on sea and land, and will continue to assist them by every means in their power."

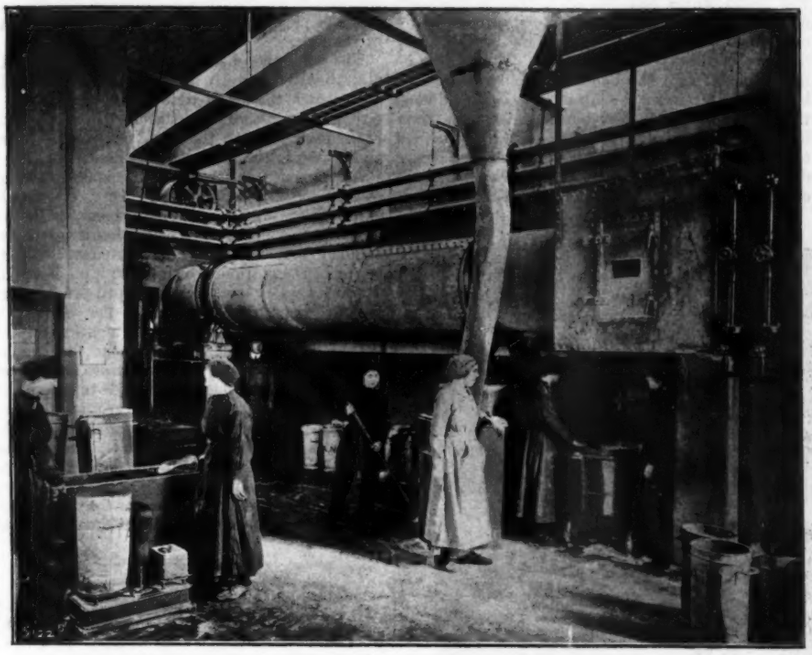


FIG. 15. AMMONIUM NITRATE DRYING ROOM, NATIONAL SHELL-FILLING FACTORY.

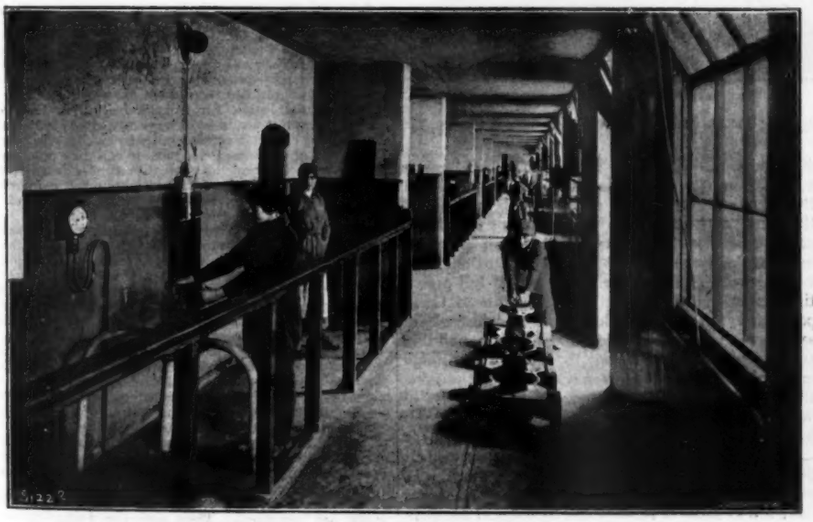


FIG. 16. FILLING SHELLS WITH EXPLOSIVES IN LIQUID FORM, NATIONAL SHELL-FILLING FACTORY.

The first two illustrations, Figs. 1 and 2, on Plate L, are views of an entirely new howitzer shop at one of the Vickers' establishments, while the illustrations, Figs. 3 and 4, on Plate LI, and Fig. 5, Plate LII, show the representative howitzers produced in this factory. The building of this howitzer shop was commenced in August, 1915, the site being a private wooded park, and the building, which is admirably designed and completed in a thoroughly permanent character, has an area of 172,000 sq. ft., made up of 15 bays, all of uniform dimensions and equipped with overhead electric travellers, and the machines specially designed for the manufacture of the various units of howitzers. When the firm were authorised to construct this howitzer shop they guaranteed a certain monthly output in August, 1916, but the building was so quickly erected and machine tools installed that this output was exceeded within nine months of the site being taken over by the builders. Since then there has passed from this shop a considerable part of the field and howitzer equipment of the British Army. Much of the important work, even in this department, is carried out by women machine workers, under the supervision of male trained experts, who are doing in this way a great and loyal service for their country. The proportion of men who take the narrow view on dilution on war and emergency work is small, but they make up for this by aggressive action. As regards the illustrations of the howitzers, the views are almost self-explanatory. In any case it is not permitted to enter into detail as regards their design, but further proof of their efficiency is given by the fact that these weapons, with British gunners, have just gone to add to the driving power of our Allies on another front. All the units of naval as well as of land guns are produced within the works, where there are extensive iron, steel and brass foundries.

Practically all the departments of the works have been extended. The area of the works at Barrow-in-Furness prior to the war was 220 acres, which has been extended during the war to 270 acres. The floor area of the workshops has increased from 1,600,000 sq. ft. to 2,400,000 sq. ft. The number of employees has gone up from 17,000 in 1914 to 35,000 at the present time. The weekly wages bill, which was 35,000*l.* in 1914, is 92,000*l.* at the present time. Since January, 1915, there have been produced 13,000 tons of howitzer equipment, and many million shells, from the largest to the smallest.

Amongst other new departments at the Vickers' works is an entirely new projectile factory having a floor area of nearly 250,000 sq. ft. Prior to August, 1914, the shell department of the Barrow works was of quite small dimensions, but immediately after the outbreak of war it was realised that immense supplies would be required, and the firm were instructed to lay down the new shell shop illustrated in Fig. 6, Plate LII, and Fig. 7, Plate LIII. The foundational work was commenced in October, 1914, and the output of the large-size shell was very considerable by the spring of the following year. The view Fig. 6, which shows the preliminary examination of shells for the Russian army, was taken five months after the site was occupied, and demonstrates the remarkable activity of the building operations, which were carried out by Messrs. Sir William Arrol and Co. There are eight bays, ranging in length from 400 ft. to 475 ft., with a gallery 270 ft. long by 60 ft. wide; there the smaller shells are manufactured entirely by female labour. A large new power station had to be erected for this shell shop, and hydraulic presses for forging the shells. Perhaps the most remarkable feature is the variety of sizes of shell turned out in this one department. Incidentally, too, it may be said that the company, having a completely experienced staff, prior to the war, for the production of shells, were able to give,

for the benefit of other firms with no experience, the nucleus of shell-manufacturing staffs, and in this way their indirect services were of as much influence as the direct production of shells of all sizes at their own establishment.

The photographs reproduced in Figs. 8 to 10, Plate LIII, and Figs. 11 to 14, page 500, illustrate the National Projectile Factory which was constructed, equipped, and is still managed by the Vickers Company on behalf of the Ministry of Munitions. The work of erecting the building was commenced on September 2, 1915, and the first shell was turned out on March 5 following. Fig. 8 shows the progress made in about five months in the department for medium-sized shells and Fig. 9 the same department six weeks later. This is one of 20 bays of similar construction. The machine bays range in length from 600 ft. to 925 ft. and in width from 50 ft. to 38 ft. The bays in the hydraulic press shop (Fig. 10, Plate LIII), where the shells are forged, are all about 240 ft. in length, but vary in width from 16 ft. to 50 ft. according to the size of the shell forged and of the hydraulic presses. The total area of the factory is 37¼ acres, while the floor area of the building is 12¾ acres. It was found necessary to erect and equip a large power station, with all accessories, as there was not a supply of power available from outside sources. The station, which has a power plant of 6,000 h.p., has powerful pumps for supplying pressure water to operate the forging presses, electric generators for providing current for driving machine tools and lighting the buildings, and air compressors for working a variety of pneumatic tools. The one interesting feature of this, as of other national factories, is the equipment of appliances for the handling of material. Practically every machine tool is fitted with a crane, so that the women workers, who predominate in the establishment, are able to deal with the large shells without involving fatigue.

The raw material as it arrives in the works is dealt with by transporters, shown in Fig. 11, page 500, which traverse the complete length of the railway siding. We hope to illustrate these transporters in detail later. The material is conveyed through the shops by railways, of which there are 3½ miles within the factory.

We do not propose to enter into a detailed description of the machine tools utilised in the factory, but in Figs. 12 to 14, page 500, we illustrate three typical processes. Fig. 12 shows the press for forging large-size shells. Fig. 13 illustrates the machining of 6-in. shells, while Fig. 14 shows the method of pressing on the copper bands of large shells, a procedure which greatly interested their Majesties on the occasion of their visit to the factory.

The construction of the National Shell-Filling Factory visited by their Majesties followed as a natural sequence upon the establishment of the National Projectile Factory and the extensions of Vickers' main works, and the firm were invited by the Ministry of Munitions to lay out the factory. A suitable site was found which had the advantage of transport connection with railways, was isolated from larger centres of population, and yet was within easy distance of the workmen's houses. It was decided at the outset that the buildings should be isolated in order to minimise the effects of accident, and in the construction of the buildings and in their internal arrangement every safeguard was provided to localise the effect of accident; in some cases the division walls are of armour-plate. The total area embraced within the boundaries of the factory is 400 acres, and the floor area of the buildings is 1,000,000 sq. ft. These figures alone, with the fact that thousands of tons of traffic pass in and out of the works each day, afford some idea of the extent of the operations carried out. There are quite 150 buildings of large and substantial proportions, and yet the work of filling the shells was in full operation seven months after the site had been taken possession of. The buildings are arranged in sequence, so that the material enters one building and passes from building to building, through mechanical conveyors, never coming into the open air, and arrives at the further end of the series of buildings a completely filled shell ready for the front.

FIG. 17. STEMMING HOUSE; NATIONAL SHELL-FILLING FACTORY.

The erection of the buildings was commenced in December, 1915, and the output of filled shells was in progress seven months later. Within the works there are 11 miles of railway and 3½ miles of runways built of timber to obviate the necessity of the workers going across open ground and involving the risk of entering the buildings with grit on their boots. There are 25 miles of piping in the factory and thousands of shells are filled each day.

We reproduce in Figs. 15 to 17, page 493 and the present page, typical buildings and processes. Fig. 15 shows the drying room, where the elements of the explosive are dried, being passed through a large cylinder with the assistance of rotary conveyors, while a hot-air blast is forced from the opposite end. The next process is the mixing of the explosives, and this is followed (Fig. 17) by what is technically termed the stemming, that is to say, pounding of the explosive into the shell by boxwood rammers; the final stage in filling, however, is done under hydraulic pressure in order to ensure the required density in packing. Some of the shells, however, are filled with the explosives in liquid form, and this process is illustrated in Fig. 16. The shell is under the floor-level and therefore cannot be seen. The explosives are allowed to cool and solidify inside the shell. The last operation on the shell, whether dried or liquid explosives are used, is the fitting of an exploder and the sealing and the plugging of the shell ready for the fitting of the fuse.

The paint shop has an area of 66,700 sq. ft. Their Majesties were much impressed with the rapidity with which the shells were painted by hand; one girl made a record by painting 54 in one hour, a result partly due to the cleverness of the operator and partly to the form of brush used.

An immense power-generating station had to be constructed, and the feature here, as elsewhere, is the great economy of man-power, as the whole of the coal required for this station is mechanically handled and fed into the furnaces. The total power of the station is over 4,000 h.p., and 150,000 gallons of water have to be pumped per day for the various purposes throughout the works. Two interesting accessories may be mentioned: First, the ambulance room, and, second, the laundry, where the uniforms of the workers are, twice weekly, washed, pressed and subjected to fire-resisting mechanical treatment. There are also extensive canteens for men and women, and fully two-thirds of the employees are women. Their Majesties were much struck with another phase of the situation. The space between all the buildings is being farmed under a market garden system for the supply of food material for the district, a total area of 100 acres being farmed.

THE METRIC SYSTEM.

TO THE EDITOR OF ENGINEERING.

SIR,—Although seriously handicapped by time and distance, I cannot refrain from replying to the editorial on "The Metric System" which appears in your impression for March 30.

With you, as with us, the great cry of the metric party in support of their system is the assumed needs of export trade. As regards this, let me say frankly that there is a certain amount of information, as distinguished from construction, that should be given to a foreign buyer in his own units of measurement, be they metric or non-metric. Of machine tools, for example, the capacity or dimensions of the largest piece of work to which they are adapted, the dimensions of the space occupied and the weight should be given in the customer's units. We print our catalogues for foreign buyers in their own languages, and it would be of large advantage to ourselves if we could conduct correspondence in those languages. This most of us cannot do, but we can give commercial and general information and invoice goods in foreign weights and measures. This is the most common of common-sense to do, and this is all there is of the foreign-trade myth.

To say that this involves the adoption of the metric system is equivalent to saying that the printing of catalogues for, or the writing of letters to, Spanish America in the Spanish language involves the adoption of that language. To say that the steel mills of Sheffield and Pennsylvania shall change their entire mill practice and procedure in order to invoice shipments in metric instead of English tons is worse than absurd, it is silly.

How little bearing this commercial information has on mechanical construction is shown by the experience of American machine tool builders. Twenty years ago there began one of the most striking of our export trade developments—the export of machine tools to European countries, France and Germany being our leading customers. This great movement continued down to the opening of the present war, which stopped it to Germany, but accelerated it to France. However, this influence being abnormal, it should be ignored.

Machine tools are the machines with which machine shops are equipped. They are the embodiment of accurate measurements, and, more to the point, on them all other machines of whatever kind and purpose are made and the dimensions of their parts determined. There is scarcely a modern industry that does not take its roots in the machine shop. Navigation, railroads, mining, printing, even agriculture as practised to-day, and war, as the world has recently learned, are children of the machine shop. Here, if anywhere, the need of the adoption of the metric system should be paramount, but what are the facts? Certain of these machines, notably lathes and milling machines, contain measuring and adjusting screws (lathes two, and milling machines three), and these in some (but by no means all) cases have been ordered to metric pitches. The pitches of such screws comprise all of the thousands of dimensions of these machines that have needed change. Even the screws have been unchanged except for the single dimension of the pitch. Apart from this, these machines

have proved just as acceptable to French and German as to American and English customers.

These facts are officially certified in a series of resolutions of the National Association of Machine Tool Builders, which contain the following :—

"The sale of many million dollars' worth of machine tools has been made abroad by members of this association, especially to France and Germany, without requirement or request by the purchasers for changes in general construction to conform to metric measurements, the only changes being in adjusting and measuring screws, the great majority of machines needing no changes whatever."

If confirmation of this be needed, it is found in the following from Laurence V. Benet, engineer of Hotchkiss et Cie, the great French ordnance makers :—

"We are using a very large amount of American machinery in our works, and the fact that this was all built to English dimensions has given no difficulty. . . . All of the newer and most up-to-date establishments in France, including all of the Government establishments, are largely equipped with American machinery, and I know of no case where the fact of the machines being built to English measures affected their saleability."

In the machine shops of South America—of which there are more than most people realise—39.3 per cent. of the machine tools are American, 43.2 per cent. are British, and the remaining 17.5 per cent. are German, Belgian and French. We are always told that South America is metric; South American shops have the world from which to buy, and they choose machine tools made to English over those made to metric measures in the ratio of over five to one. Moreover, commercial Germany has long been splendidly represented in South America, while we have never been, and Germany has had ample shipping and banking facilities, which we have not.

Another illustration, known to all, is found in the vast export trade in American automobiles, which go to, and are equally acceptable in, all countries, metric and non-metric alike. No one knows, asks or cares to what system of measurements their parts are made,* and the same is true of steam engines, mining, agricultural and other lines of machinery. The matter is as broad as it is long. If our goods are not acceptable in metric countries because of the units in making them, metric goods should for the same reason be unacceptable here. We import vast quantities of such goods, but no reader of these pages ever heard the question raised. We buy these goods without thought or question regarding the system of measurements used in their construction.

At the end of your editorial I find a frank admission of the fundamental situation in your sentence : "In no country was the change so difficult as it will be here, for in none was manufacturing so highly organised." At the origin of the metric system there were but two industries which could in any sense be called organised, namely, the textile industry and the building trades, and this condition was substantially true in Germany when the metric system was adopted there. Should the reader doubt this, he should consult the scathing report of Dr. Franz Reuleaux, who was the German Commissioner at our Centennial Exhibition in 1876. His denunciation of the primitive character of the German mechanical exhibits at that exposition is a classic, and it has been credited with the German awakening which led to the introduction of modern machine construction in that country. The point I now make, however, is that, as shown by this report, the metric system was adopted in Germany before mechanical construction had made any considerable progress there.

In France and Germany alike, then, the textile industry and the building trades were the only organised industries in which measures played a large part at the time of the adoption of the metric system, and it is precisely on those industries that the system has made substantially no impression.

It is now established that the silk industry of France—the largest industry in that country—is based upon the old French units, the cotton industry of Germany upon the English units, and the woollen industry of Germany on the old German units, while the building trades of Germany are based upon the Rhenish inch. In all cases these are the units used by these industries when the metric system was adopted. Closely related to the building industry is, of course, the lumber trade. My information regarding the lumber industry of France is lacking, but, with the possible exception of that country, it is true that metric lumber cannot be found in the markets of the world. During my investigation of fifteen years I have found no case of an industry which could fairly be called organised which has changed its weights and measures.

Your editorial closes with the sentence : "Our own impression is that the cost will be found to be very much less than many anticipate." A dozen years ago, during the last acute agitation on this subject, the Westinghouse Electric and Manufacturing Company and the Yale and Towne Manufacturing Company caused estimates—no guesses—of the cost of changing to be made by the heads of their various departments. The result in the former case was between one-half and three-quarters of a million dollars, and in the latter case between 300,000 and 400,000 dols. The cost from a national standpoint would be simply appalling; but more than this, and regardless of cost, there are the numberless applications in which the simple necessity for continuity between new and old constructions makes the change physically impossible. In such applications the old units must be continued—a condition which it is now proposed to recognise and legalise by certain exceptions in the Bill before the British Parliament. Whether the continuance of old units is in defiance of law or by virtue of law does not change the final result, which would be that your manufacturers would buy their raw material and sell their finished products by the metric system and conduct their intermediate factory work by the English system.

Only thorough students of this subject have any moral right to discuss this phase of it. The man in the street, and, much more, the engineer, should study what is now known of the results of this condition before expressing an opinion upon it. It is precisely this state of affairs among the textile industries of metric Europe which Mr. S. S. Dale has laid bare, and no one can study his disclosure, not of an industry but of a condition, without recoiling from the effort to introduce the same condition in English-speaking countries.

The persistence of old units in metric countries is the outstanding fact, and it relegates all other phases of the discussion to the out-of-date. The only questions now remaining are : What are the consequences of a mixture of systems, and do we want that mixture ? When we learn what the mixture means, we will, one and all, decide that we do not want it.

Yours very truly,
F. A. HALSEY,
Commissioner, American Institute of Weights and Measures.

American Institute of Weights and Measures,
20, Vesey-street, New York, April 30, 1917.

* Except, of course, as regards the tyres, which should be made to conform to local usage.

"THE ELECTRICAL PROPERTIES OF GASES."

TO THE EDITOR OF ENGINEERING.

SIR,—Probably, in view of what Wendell Holmes has called the hydrostatic paradox of newspaper controversy, there is some degree of rashness in venturing a reply to the letter of "Earnest Student" published in your issue of May 18 last. However, I will risk the disadvantage to which Dr. Holmes referred and point out that the answer to your correspondent's queries is very easy. We know that electricity is atomic in structure in exactly the same way and in the same sense in which we know that Newton's laws hold for the whole extent of the solar system and far beyond (at least as a very close first approximation). In both cases the conclusion is reached as the result of making quantitative comparison between observation and calculation based on hypothesis. If "Earnest Student" is not a mere crank it would be interesting to learn the precise significance he attaches to the word "know." The only things we really *know* are our own thoughts, as all our "knowledge" of the external world is not knowledge but hypothesis. The evidence which leads a labourer to believe in the existence of a particular bar of iron does not differ in *kind* from that which leads the chemist to believe in the existence of atoms or the physicist in the electron. In both cases the conclusion results from an analysis of certain mental impressions. The sole difference is that in the one case the evidence is as direct and crude as that which led our ancestors to believe in a geocentric universe, whilst to appreciate the weight of evidence in favour of the atom or electron requires not merely intelligence, but also application. Even in such a relatively simple matter as a game of chess the would-be critic, whatever his native intelligence, must study for years before he is in a position to express an opinion of value.

Our whole knowledge of the external world being necessarily hypothetical, no scientific theory can, of course, be true in the sense in which a religious or political creed is true to its adherents. The test of a scientific theory is, does it work ? There is no evidence which conflicts with the existence of the electron or with the complicated structure attributed to the atom, and much evidence in favour of these views, which no one has succeeded in explaining on any other tenable theory, whilst predictions based on these hypotheses have been repeatedly confirmed by observation, just as has happened with the laws of gravitation. It is thus permissible, in order to avoid the use of lengthy parentheses, to state that we "know" the law of gravitation to hold, or that the electron exists, though in the strict sense of the word each of us knows only his individual thoughts.

In but one point is the present writer in agreement with your correspondent, viz., in attributing to Sir J. J. Thomson extraordinary imaginative insight into the apparent mechanism of Nature, which, indeed, amounts at times almost to inspiration. That the whole progress of science depends upon the scientific use of the imagination was pointed out by Tyndall years ago. He was misunderstood (perhaps wilfully) by his clerical commentators, and possibly "Earnest Student" may in this connection aid history in her supposed desire to repeat herself.

Though he professes to be an ignoramus, I judge from the tone of his letter that "Earnest Student" believes he *knows* many things, so sign myself as

DIDYMUS.

TO THE EDITOR OF ENGINEERING.

SIR,—The articles on Sir J. J. Thomson's lectures remind me of the "Relativist" correspondence which appeared in your columns a few months ago ; and I agree with "An Earnest Student" as to the present generation of physicists going beyond what Tyndall called the "scientific use of the imagination."

As children we loved fairy tales ; but try to realise the mental condition of "grown-ups" who see nothing silly in such remarks as appear on page 478, in the current issue of ENGINEERING :—"By applying to such a gas a suitable electric field it was, however, possible to make each charged particle 'breed'—becoming thus the ancestor of a very numerous family. Under such conditions we might, in fact, get from the original particle a million of descendants."

Is the president of the Royal Society really responsible for this statement ?

London, May 19, 1917. SESAMY.

DRAUGHTSMEN AND FOREMEN.

TO THE EDITOR OF ENGINEERING.

SIR,—The allusion to Professor Ripper's plea for the draughtsman in last week's issue is interesting. I can recall no other instance of so frank and forcible a claim on the draughtsman's behalf. It is as refreshing in its novelty as it is significant in its tenour. It will come as an awakening and a consolation to thousands who, because of their unfortunate position on the unproductive side of an engineering establishment, and accustomed as they are to hear little besides the financial director's periodical complaint of drawing office expenses, and his insistence upon the necessity for reducing them, have come, in course of time, to accept his estimate of themselves as a sort of necessary evil, to be borne with because you cannot do without them, and to work meekly in an atmosphere of mild reproach.

Doubtless the draughtsman is largely responsible for his own position. Whether it has been true humility of spirit that has led him to bend his neck for the yoke, or whether it has been the belief that his individual ability must some day find recognition, and that the time will come when he also will rank with those who control the destinies of the draughtsman, and, in turn, have the privilege of urging the curtailment of establishment charges, is not for me to decide, but in either case he deserves his fate. Extreme patience is apt to be associated with long ears, and there is nothing very regrettable in the failure of a selfish ambition. Nor is his gullibility a very admirable quality. How often have I heard him told that his interest in his work and his loyalty to the firm should make him willing and eager to give his spare time without so sordid a thought as monetary recompense. Even your own columns have urged him to exalt his trade into a profession, and to work in the same noble spirit with which the doctor heals and the barrister pleads. Yet one never hears that either of these gentlemen is regardless of the financial aspect of his efforts. On the contrary, one hears of powerful associations in connection with medicine and law—"trade unions" would be perhaps too harsh a term—that do most effectively protect the interests of their subscribers. And I wonder if it would be too picturesque to say that very many of the doctors "went on strike" because the terms of the Insurance Bill were not sufficiently generous ?

Let us, by all means, aspire to the professions. The ability required, the responsibilities undertaken, the small numerical proportion of the drawing-office staff to the shops, who are entirely dependent on it for guidance and information, the extreme and beneficent usefulness of the draughtsman's work in times of peace and its supreme importance in times of war, should make such a claim indisputable. But until this world is run upon different principles let not the draughtsman confound the substance with the shadow. All things rest upon an economic foundation, and the draughtsman contends with an astute opponent, who, however desirous he may be of fostering a fine sentiment, would nevertheless prefer that the sentiment should not be disadvantageous to himself. May I quote an instance ? Leaving certificates. Do we not remember what an excellent thing competition was before the war—how stimulating, how productive of efficiency that many draughtsmen should be applicants for the same vacancy ? Alas, when it came to pass that there were not enough draughtsmen to go round, when the competition *changed sides*, when there was a prospect of firms bidding against one another for the draughtsman instead of draughtsmen for the firm, all the virtue went out of competition. Then it was that the old rules of the game were suddenly altered, and the clearance certificate bound the man to the office *so long as it should suit the office to retain him*. One of our pet complaints against the German is his unsportsmanlike conduct in altering the rules of war when they act to his disadvantage. One might almost detect a similarity here—if it were not unpatriotic to suggest such a thing.

ERNEST H. WALKER,
President, London Council A.E.S.D.

61, Claverton-street, South Belgravia, S.W. 1.
May 21, 1917.

LUMINESCENCE OF MERCURY COMPOUNDS.—When Nessler's reagent, an alkaline solution of mercuric potassium iodide, is treated with ammonia, a precipitate is formed which becomes luminous when heated. Studying this phenomenon, Dr. Harry B. Weiser (*Journal of Physical Chemistry*, January, 1917) finds that the compound, known as Millon's base, does not melt, as had been assumed, but decomposes, giving off nitrogen, ammonia and water, and also mercury and iodine, which condense in the colder portion, while emitting a deep violet light, especially when the temperature is raised to nearly 400 deg. C. It results that mercury is concerned in at least three luminescences. Orange rays become visible when cathode rays act on mercurous salts, or when an excess of mercury is burnt in chlorine, or when mercury is the anode in electrolysis. A green luminescence is observed when the cathode rays act on mercuric salts and when mercury burns in an excess of chlorine. Finally, the violet light is seen under the conditions mentioned. The orange luminescence seems to mark the passing of mercury ions into mercurous salt ; the green light the change of mercurous into mercuric ions ; and the violet luminescence the transition of mercuric ions into mercury.

THE RAYMOND CONCRETE PILE.

CONSTRUCTED BY THE RAYMOND CONCRETE PILE COMPANY, NEW YORK, U.S.A.

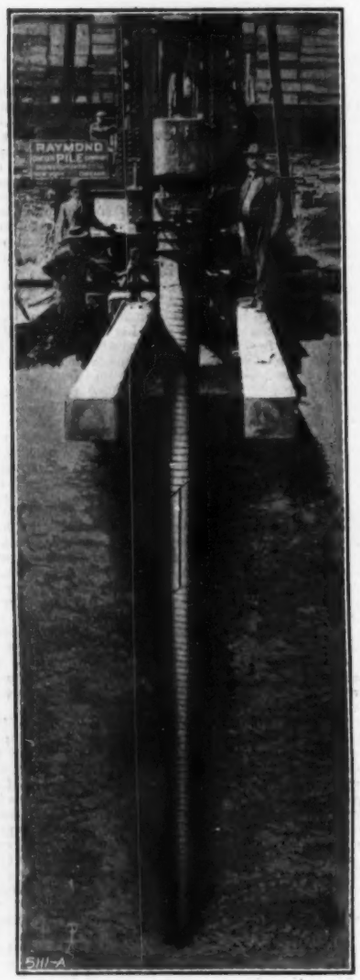
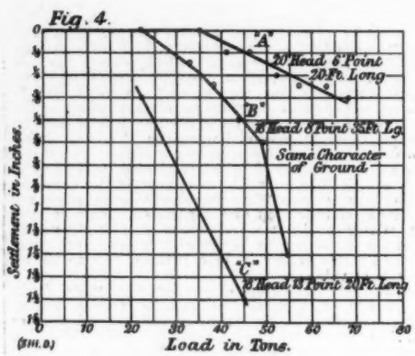


FIG. 1.

FIG. 2.



WE illustrate on this page a type of foundation pile which has been used in the United States for a number of important structures erected during the past 15 years. The pile in its finished condition consists of a wall of thin sheet steel surrounding a core of concrete. This concrete is, however, added only after the steel sheathing has been driven to the depth desired. For driving the sheathing is strung, in a succession of lengths which telescope into each other, on to a tapered core of steel made in halves, so as to be readily withdrawn. The construction is perhaps best seen in Fig. 1 above. In this a portion of the sheathing near mid-length of the pile is represented as broken away, so as to show more clearly the inner steel driving core. By preference a steam-hammer pile-driver is used, but the ordinary falling tup machine can also be adopted, though the rate of sinking is less rapid. When the desired depth is attained the steel core is collapsed and withdrawn ready for use again. The interior of the tapered sheathing, which remains behind in the ground, is then filled up solid with concrete. An advantage claimed is that it is quite easy to examine the condition of the sheathing before concreting, either by reflecting daylight down it or by the use of artificial light. Three lengths of sheathing are shown in Fig. 2, whilst Fig. 4 shows the reinforcing helix of hard steel wire which ensures the radial stiffness of the sheath. This is sufficiently great to withstand all ordinary service conditions. The collapsible steel cores used in driving the piles are 8 in. in diameter at the bottom and 20 in. in diameter at 30 ft. up, so that a pile 20 ft. in length measures about 16 in. in diameter at the top, and one of 37 ft. nearly 23 in. at top level. The latter pile is the longest of the type yet driven. Many engineers believe that, in certain materials, parallel piles are superior in supporting power to tapered ones. In Fig. 4 we reproduce curves obtained in a comparative test in a case in which the responsible engineer had expressed a preference for parallel piles. Two piles were driven into the same ground a few feet apart. Both were 20 ft. long. One had a core diameter of 6 in. at the point and 20 in. at the top, whilst in the case of the other the core was 13 in. in diameter at the point and 18 in. at the tip. This required 944 blows of a steam hammer to secure a penetration of 20 ft., whilst the one with the smaller point was driven with 875 blows. A month later both were tested by loading, and the settlement measured. The results obeerved are plotted in Fig 4, where the A refers to the pile with the coarser taper and C to the nearly parallel pile. It will be seen that the settlement was much less with pile A.

The curve B refers to another experiment on ground of the same character. Here the pile was 35 ft. long, 8 in. in diameter at bottom and 18 in. at top, so that the taper was less than it was in case A. The latter, though driven to 20 ft. depth only, held up distinctly better under load, as the graphs show. The pile has been introduced by the Raymond Concrete Pile Company, of 140, Cedar-street, New York.

THE SUPPLY OF ELECTRIC POWER.

A COMMITTEE was recently appointed by the Board of Trade "to consider and report what steps should be taken, whether by legislation or otherwise, to ensure that there shall be an adequate and economical supply of electric power for all classes of consumers in the United Kingdom, particularly industries which depend upon a cheap supply of power for their development." The committee having held several meetings and considered the results of certain investigations that have been previously undertaken, have unanimously come to the following conclusions:—

1. That when British industry is subjected to the test of keen international competition, after the war, its success will depend upon the adoption of the most efficient methods and machinery, so as to reduce manufacturing costs as much as possible.

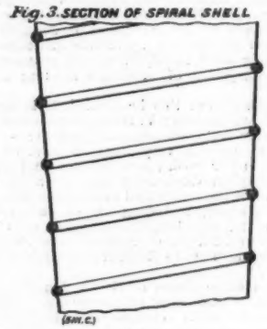
2. That a highly important element in reducing manufacturing costs will be the general extension of the use of electric power supplied at the lowest possible price, and it is by largely increasing the amount of power used in industry that the average output per head, and as a consequence the wages of the worker, can be raised.

3. That the present system, under which a supply of electricity is provided in a large number of small areas by separate authorities, is the result of a policy adopted at a time when the applied science of electrical engineering was in its infancy, and is incompatible with anything that can now be accepted as a technically sound system.

4. That the interconnection of existing electric supply stations recommended by the Board of Trade in their letter of May 25, 1916, however desirable in itself, cannot alone meet the requirements of the situation.

5. That a comprehensive system for the generation of electricity, and where necessary reorganising its supply, should be established as soon as possible.

The committee have decided to invite representative associations throughout the country to give evidence before them with regard to the best methods of giving effect to these conclusions.



THE INSTITUTION OF GAS ENGINEERS.—The annual meeting of the Institution of Gas Engineers is to be held on June 5 at the Institution of Civil Engineers under the presidency of Mr. A. E. Broadberry, M.Inst.C.E., engineer and general manager to the Tottenham District Light, Heat and Power Company. After the president's address has been delivered the annual report of the council is to be presented, followed by reports of the three research committees of the Institution, viz., Refractory Materials, Gas Lighting, Heating and Ventilation, and Life of Gas Meters. The annual meeting of the contributors to the Benevolent Fund will be held during the morning. On the following day a visit is to be paid to the gas and electricity works of the president's company. On Thursday morning a general meeting of the joint commercial sections is to be held at the offices of the Institution, 39, Victoria-street, Westminster. The Right Hon. Lord Moulton, K.C.B., F.R.S., Director-General of Explosives Supply of the Ministry of Munitions of War, has been nominated for election at the meeting as president for the year 1917–18.

ELECTRIC HEAT STORAGE IN BOILERS.—Last October the Swiss Association of Boiler Proprietors conducted some experiments on an electrically heated steam boiler. It was a cylindrical boiler with flat ends, 1,250 mm. long, 600 mm. diameter, provided with 38 tubes of 27 mm. internal diameter. Up to 34 of these tubes were electrically heated by inserting spirals of 0.9 mm. nichrome wire in the tubes. Continuous current was supplied at 226 volts, the mean current intensity was 142 amperes (ranging from 92 to 200); steam was generated at about 2 atmospheres, and in the test case 10,207 kg. of water of 0 deg. C. were converted into steam of 100 deg. per kilowatt-hour. Assuming a theoretical evaporation of 859 cal. per kilowatt-hour, the evaporation efficiency realised was 90.5 per cent., which was satisfactory considering the difficulties of insulation and of prevention of heat losses. But electric heating is notoriously wasteful. Yet in view of the actual high fuel prices in Switzerland, Mr. E. Höhn, of Zürich, calculates, in the *Schweizer Bauzeitung* of April 28, 1917, whether it would be advisable to store the spare energy from electric and hydro-electric power stations in steam boilers. He arrives at the conclusion that this storage in thermally well-insulated boilers larger than the one mentioned would be recommendable. The boiler tubes he would make of hard-drawn brass; iron would not be suitable for alternating currents.

THE PRESTWICH FLUID GAUGE.

CONSTRUCTED BY MESSRS. J. A. PRESTWICH AND CO., ENGINEERS, LONDON.

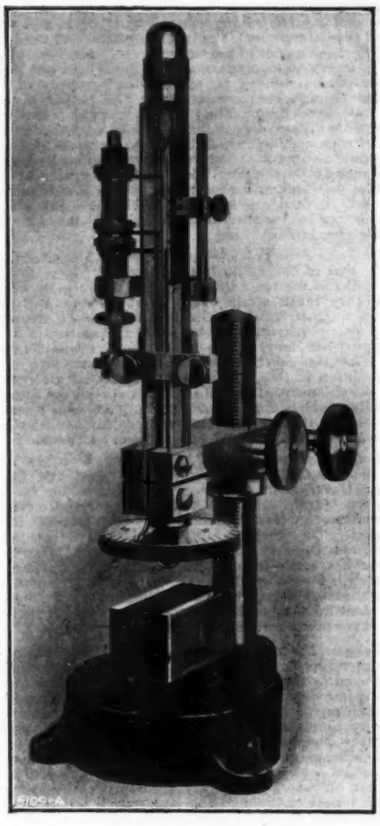


FIG. 1.

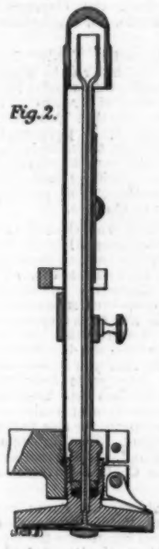


Fig. 2.

WE illustrate on this page a new and very interesting gauge for measuring with great accuracy the dimensions of small objects in rapid succession. It not only tells if an object—say a pin—is within the limits of tolerance, but it tells exactly how far it departs from the precise dimension, whether within or beyond the permitted divergence. The apparatus is quite robust, and, with reasonable care, should not suffer from wear during a long period.

The principle upon which the gauge is founded has already been largely utilised in America in the construction of testing machines, and its trustworthiness has been established. A small quantity of fluid is enclosed in a chamber, the lower face of which is formed by a flexible metal diaphragm carrying a knob or pip in its centre. From the upper side of the chamber there rises a glass tube, like a thermometer tube, which is partly filled with the same fluid as that in the chamber. Any pressure exerted on the elastic face of the chamber will force the fluid higher in the tube, and as the bore of the tube has a known relation to the capacity of the chamber the amount of movement of the diaphragm can be read off on a magnified scale. The magnification depends on the bore of the tube, and varies as desired between 500 and 1,200.

At some distance below the chamber is a hardened steel anvil on which the object to be measured or tested is laid. The distance between the anvil and the knob on the diaphragm can be varied by a rack and pinion, which moves the chamber and diaphragm up and down as desired, after which it is clamped fast. There are three adjustable pointers on a vertical carrier beside the tube. The lower pointer is set to the level of the liquid in the tube, and shows whether any correction for temperature is needed as the work progresses. The other two pointers indicate the limits of tolerance, and when a piece of standard size is passed over the anvil the liquid should rise to a level midway between these two pointers. A scale reading to ten-thousandths of an inch is fixed alongside the tube.

It will be seen that the instrument, which is manufactured by Messrs. J. A. Prestwich and Co., of Northumberland Park, Tottenham, has a wide field of usefulness, and that by the use of a variety of anvils it will deal with many kinds of work.

THE PHYSICAL SOCIETY OF LONDON.

AT the meeting held on Friday, April 27, 1917, at the Imperial College of Science, Professor C. V. Boys, F.R.S., president, in the chair, a paper entitled "*A Note on the Derivation of the General Equation for Wave Motion in an Elastic Medium*" was read by Professor J. A. Fleming, M.A., D.Sc., F.R.S.

The paper explains a simple method of arriving at the general differential equation for wave motion, viz.,

$$\frac{d^2\phi}{dt^2} = c^2\left(\frac{d^2\phi}{dx^2} + \frac{d^2\phi}{dy^2} + \frac{d^2\phi}{dz^2}\right),$$

where c is the velocity of propagation of the wave. A wave motion consists in the propagation of some form of strain through an elastic dense medium or one having comparable qualities. Corresponding to this strain there is an analogous stress in the medium, and we can express this stress mathematically in two ways, viz., kinetically, as the product of the density and the time rate of change of the strain, or by $m\frac{d^2\phi}{dt^2}$ per unit of volume, and also statically as the space increment of the expression $e\frac{d\phi}{dr}$ where e is a coefficient of elasticity and r is a vector denoting direction of propagation. Hence for plane waves we can write the equation

$$m\frac{d^2\phi}{dt^2}\delta r = \frac{d}{dr}\left(e\frac{d\phi}{dr}\right)\delta r,$$

or if m and e are independent of distance, we have

$$\frac{d^2\phi}{dt^2} = \frac{e}{m}\frac{d^2\phi}{dr^2},$$

which is the known differential equation of wave motion for plane waves. Its solution is

$$\phi = \mathrm{F}\left(x \mp \sqrt{\frac{e}{m}}t\right),$$

where F is some function. In the same manner for spherical waves originating in a point source we can write the stress equation

$$4\pi r^2 m\,\delta r\frac{d^2\phi}{dt^2} = \frac{d}{dr}\left(4\pi r^2 e\frac{d\phi}{dr}\right)\delta r,$$

which at once gives

$$\frac{d^2\phi}{dt^2} = \frac{e}{m}\left(\frac{d^2\phi}{dr^2} + \frac{2}{r}\frac{d\phi}{dr}\right);$$

or if $r^2 = x^2 + y^2 + z^2$, we have

$$\frac{d^2\phi}{dt^2} = \frac{e}{m}\left(\frac{d^2\phi}{dx^2} + \frac{d^2\phi}{dy^2} + \frac{d^2\phi}{dz^2}\right).$$

The solution of this last equation is

$$\phi = \frac{1}{r}\mathrm{F}\left(x \mp \sqrt{\frac{e}{m}}t\right),$$

where F is some function.

The general equation for electromagnetic wave propagation in a pure dielectric may also be obtained in the same manner. In this case the strain on the medium is the electric displacement D, and, if E is electric force, then on a system of rational units 1/K, where K is the dielectric constant, is the electric elasticity. Hence we can consistently assume that the magnetic permeability μ corresponds to density, and then the kinetic measure of the electric stress is $\mu\frac{d^2\mathrm{D}}{dt^2}$, and this must be equated to the space variation of the static measure of the electric stress.

For the spherical wave from a point source this leads to the equation

$$\frac{d^2\mathrm{D}}{dt^2} = \frac{1}{\mu\mathrm{K}}\left(\frac{d^2\mathrm{D}}{dx^2} + \frac{d^2\mathrm{D}}{dy^2} + \frac{d^2\mathrm{D}}{dz^2}\right),$$

where the solution

$$\mathrm{D} = \frac{1}{r}\mathrm{F}\left(x \mp \frac{1}{\sqrt{\mu\mathrm{K}}}t\right).$$

The wave is, therefore, propagated outwards without change of wave form; but the amplitude varies inversely as the distance from the source.

Since the Laplacean operator $\frac{d^2}{dx^2} + \frac{d^2}{dy^2} + \frac{d^2}{dz^2}$ is an invariant, and is not altered in form by a shift of origin; and since we can by Huyghen's principle consider a wave of any kind as the resultant of a set of spherical waves originating at various point sources, we can apply the above method to the case of wave motion generally.

The method above described may be epitomised by saying that we obtain the differential equation by equating the product of strain-acceleration $\frac{d^2\phi}{dt^2}$ and density to the static measure of the stress expressed as the space variation of the product of the elasticity and the strain slope $\left(e\frac{d\phi}{dr}\right)$, which is the proper measure of the stress at the point considered.

Mr. F. J. W. Whipple thought that the validity of Professor Fleming's application of Huyghen's principle might be questioned. In the first place, he thought that the principle itself required proof just as much as the property that it was used to establish. Further, the secondary wavelet from each point in a wave front was assumed to be spherical. Was it not the case that the phase of these disturbances was a function of the direction, relative to the main wave front, as well as of the distance from the origin of the wavelet? Another interesting question was how the equations would have to be modified in the case of the energy reflected at the boundary surfaces of the medium.

Professor C. H. Lees did not quite see how Professor Fleming's treatment of the problem differed from that given in Love's "Elasticity," for example.

Professor J. A. Fleming, in reply, wrote that the criticisms of the two speakers in the discussion rather missed the point of the paper. The validity of Huyghen's principle was not in question. Most writers on physical optics had resorted to it, and he (Dr. Fleming) had never seen any explanation of the phenomena of diffraction which did not rest upon it. The proof given in the paper that the characteristic equation proved for spherical waves with origin at the centre might be applied to waves however originating was made to rest upon the fact that the Laplacean operator was invariant with regard to origin. The object of the paper was not to write a complete theory of wave motion, nor of elasticity, but merely to give a method, which seemed valid, for arriving immediately at the characteristic equation in a manner which would appeal to students not very well versed in hydrodynamics or the theory of elasticity. Professor Lees asked how far the treatment differed from that given, say, in Love's "Theory of Elasticity." The answer was, not at all in the result; but the method used in the paper enabled us to arrive by simple considerations at the characteristic differential equation, and then to elucidate the physical meaning of its solution. It seemed better for a physical and engineering student to have some approach to such conception rather than none at all. The treatment of the subject of wave motion was generally very difficult to follow in advanced text-books, whereas the practical applications of sound, water and electromagnetic waves made some theoretical knowledge of the subject necessary.

A paper entitled "*The Effect of Stretching on the Thermal Conductivity of Wires*," by A. Johnstone, B.Sc., was read, in the absence of the author, by Professor C. H. Lees, F.R.S.

In the experiments carried out the wire to be tested was fixed at each end between the jaws of screw clamps joined to brass cylinders, through which water could be circulated. Attached to one clamp was a rod passing through a framework, enabling tension to be applied by a nut working on a thread.

Heat was supplied to the centre of the wire by passing a current of electricity through a manganin coil wound on the wire, and the temperature difference between two points on the same side of the centre was ascertained by two platinum coils, also wound on the wire.

The resistances of the coils were determined by means of a Callendar-Griffiths bridge, enabling a temperature difference of 0.01 deg. C. to be read, and making it possible to detect a difference in conductivity of 0.05 per cent. If R_1 is the resistance of the platinum thermometer nearer the heating coil, and r_1 is that of the other platinum coil when both are at the jacket temperature; and if R_2 and r_2 are corresponding values when a temperature difference exists, then it may be shown that the conductivity

$$\mathrm{K} \text{ is proportional to } \left(\frac{\mathrm{R}_2}{\mathrm{R}_1} - \frac{r_2}{r_1}\right)^{-1}.$$

For all the wires used (copper, steel, nickel, aluminium, brass, zinc), stretching produced a slight increase in thermal conductivity. The most satisfactory experiments

showed an increase of about 0.5 per cent. for a tension of about 0.7 of the elastic limit.

After the tension was withdrawn the conductivity returned approximately to its original value.

Discussion.—Mr. F. E. Smith suggested that it would have been of interest if the author had made simultaneous observations of electrical conductivity on the same apparatus. Had any experiments been made on liquids, such as mercury, for example?

Professor Boys asked if the coefficient would be reversed if compression were applied instead of extension. He realised there would be some practical difficulties in making the experiments.

Professor Lees, in reply, said that there would have been electrical measurements included in the paper but for the author's absence in the army. He thought compression measurements could be made, though they had not so far been carried out.

A paper on "*Cohesion*" (third paper), by Professor Herbert Chatley, D.Sc., was taken as read.

The objects of the paper are:—

(*a*) To restate and add further evidence in favour of an electrical theory of cohesion.

(*b*) To provide tentative empirical formulæ for the expression of inter-molecular forces.

The author defines cohesion as the net attraction (*i.e.*, balance of attraction over repulsion) between molecules which are relatively chemically saturated, at distances not greatly exceeding the molecular diameters, and the following formula is proposed for this attraction:

$$f_2 = G m^2 / d^{(2+4d_0/d)}$$

where G is the Newtonian constant of gravitation, m the molecular mass, d the molecular interval (centre to centre), and d_0 is the molecular diameter.

Discussion.—Dr. R. S. Willows (communicated remarks) pointed out that the statement that an electrified liquid evaporated more quickly than a neutral one was not true in all cases. C. T. R. Wilson's fog experiments showed, for small drops, that evaporation was most rapid when the drops did not contain an electric ion.

M.O.M. TRACTORS.—Engineers are asked to co-operate in the manufacture of petrol tractors for farm use in order that a greatly increased acreage can be put under wheat next autumn. These tractors are to be constructed in parts, and finally assembled under the supervision of the Controller of the Agricultural Machinery Department, Manufacturing Branch, 8, Northumberland-avenue, London. Actual parts can be seen, and full drawings and specifications and forms of tender can be obtained at the Controller's office. The last day for tendering is Saturday, June 2.

THE DETERGENT ACTION OF SOAP.—The cleansing action of soap is ascribed to its being a detergent, an agent enabling us to wipe off the greasy matter adhering to the skin. Soap is considered able to do this because it contains, or liberates on contact with water, free alkali, which emulsifies the grease, breaking up the continuous film into oily globules. The surface tension between the oil and the water is lowered by the soap solution, so that the latter and the water can gain access. There may also be union of the dirt with the acid soap produced by hydrolysis. To these more or less recognised effects Mr. Spencer U. Pickering, F.R.S., in a paper presented to the Chemical Society last February, adds another, which is probably more important than some of those mentioned. He finds that oils, even paraffin oils, dissolve in soap solution and form soluble compounds containing sometimes nearly equal weights of oil and soap. As there is also emulsification, however, not all the soap is utilised in this way. The combination between soap and oil is accompanied by thermal changes (positive or negative), and depends on chemical as well as on physical properties. Naphthalene, for instance, is hardly soluble in soap, and the little dissolved naphthalene separates out again on cooling or diluting the solution, whilst solutions of paraffin in soap are not decomposed by dilution.

SOME PROBLEMS OF THE IRON OXIDES.—All metallic iron found on the earth is generally supposed to be of meteoric origin. As a matter of fact many basic rocks, especially specimens of diabase and gabbro (complex silicate rock of the hornblende type) from Greenland, frequently contain small amounts of metallic iron, reduced probably from ferrous oxide. The oxides of iron indeed still offer some unsolved problems. One would think, for instance, that the melting-point of the brown iron oxide, Fe_2O_3, apparently a stable compound and frequently used by the chemist in quantitative analysis, should be accurately known. But we see from an address delivered by R. B. Sosman before a joint meeting of the Washington Academy of Sciences and the Chemical Society (February issue of the journal of the Academy) that the melting-point can only be determined when there is a sufficient oxygen pressure to prevent dissociation. In addition to the ferric oxide Fe_2O_3 there are the ferrous oxide FeO and Fe_3O_4. The FeO is regarded as the lowest oxide; but it is more than doubtful whether anybody has ever experimented with pure FeO; Hilpert and Beyer (1911), as well as Sosman, believe that they were, in their experiments, dealing with mixtures of metallic iron (or possibly some carbide) and Fe_3O_4. Ferrous and ferric oxides seem to form a continuous series of solid solutions. On the other hand the reactions of ferrous salts and of ferric salts differ as much as if they contained different elements. Sosman, who works in the Geophysical Laboratory of Washington, is particularly interested in the equilibrium relations from the geological standpoint; but metallurgists know that they have not fathomed the iron oxide problems yet.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several Colonial and foreign engineering projects, taken from *The Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C. 2.

Canada.—The Imperial Trade Correspondent at Toronto has furnished, under date March 30, a copy of the general specifications for concrete highway bridges in Ontario, and also a copy of a report on the construction of highway bridges in that province. The second-mentioned publication is in part explanatory of the specifications for steel and concrete bridges issued by the department, and is also complementary to the series of general plans for such bridges issued annually for the convenience and guidance of municipal and other highway authorities in Ontario.

Russia.—The British Vice-Consul at Kertch reports that the Azov-Don Commercial Bank has petitioned the Kertch Municipality for the purchase of 80 dessiatines (about 216 acres) of land situated near the metallurgical works, for the construction of shipbuilding works. According to the prospectus submitted to the municipality, the enterprise will have a capital of not less than 5,000,000 roubles. Construction of the works must start within one year from the date on which the Russian Government signs the Treaty of Peace with the belligerent countries. Within four years from the date of the conclusion of peace not less than 2,500,000 roubles must be expended on the erection of works and the necessary machinery. The prospects for this enterprise are stated to be very encouraging. The municipality has agreed to cede the land required, and the matter is now awaiting the sanction of the Central Government. (Rouble = 2*s.* 1½*d.*, par rate).

Italy.—H.M. Embassy at Rome reports that the Supreme Council for Public Works has granted concessions to three local companies for increases in water-power to be derived from the River Nera, in the Province of Perugia, and from the rivers Piave and the Cordevole in the Province of Belluno. The council is further considering a number of other applications for similar concessions, and is studying the water-power possibilities of various streams in the Cuneo and Rome districts, especially of the lakes of Albano and Nemi. The names of the companies referred to may be obtained by United Kingdom firms interested on application to the Department of Commercial Intelligence. The reference number (197) should be quoted.

Japan.—H.M. Commercial Attaché at Yokohama has forwarded an extract from a Kobé newspaper, from which it appears that a large extension of equipment is projected by the Mitsubishi Dockyard and Engine Works at Kobé. This company is to build four steamers this year, ranging from 2,000 to 6,000 tons, while the construction of other vessels on its own account is also contemplated. To meet the increased demand for building capacity, the management has undertaken the construction of two new berths, and a new floating dock of 20,000 tons lifting capacity. It is said that when these projects are completed the Mitsubishi yard in Kobé will be able to build ships aggregating 60,000 tons a year. H.M. Commercial Attaché has also forwarded the following additional particulars, furnished by the company, relative to its floating dock and the new shops which are being constructed. The dock will be moored in the new basin as soon as the breakwater of about 1,000 ft. is completed. This breakwater will run from the end of Wada Point, nearly parallel with the existing inner breakwater of about the same length. A new engine shop is now being constructed with the intention of manufacturing Diesel engines for land and marine purposes, especially for submarine boats, together with petrol engines for aeroplanes, motor boats and motor cars. The new shop is expected to be finished by about the middle of this year. It has also been decided to commence the manufacture of the "8tal" type of steam turbine.

SHIPBUILDING IN THE UNITED STATES.—The announcement from Washington that the temporary suspension of construction work on the five new battle-cruisers and other capital ships for the navy is being considered will be heard with satisfaction by manufacturers, who have been watching the course of events in connection with the upbuilding of the Army and Navy, says *The Iron Age*, New York. It is well known that the largest battleships and cruisers cannot be completed in less than three years. It certainly is a reasonable hope that the great war will be ended by that time; but the main point at present is that the greatest need is facilities for building more steel merchant ships, and it is encouraging to know, adds our contemporary, that several Cabinet officers are reported to believe that drastic steps should be taken to add steel vessels to the merchant marine. Firms who have been awarded battle-cruiser contracts having agreed that 70 per cent. of their working forces would be kept continuously on Navy work, little chance remains to take contracts for merchant ships, large numbers of which have been refused. While it is not wise to check the prompt completion of fighting vessels now well advanced in construction, or to interfere with the building of submarine and other small vessels, it does seem entirely reasonable to postpone construction for a time upon the great battleships on which work has not been started. If this were done and means could be found for enlisting an army of workers in the shipyards, where working men are particularly needed, the upbuilding of the merchant marine could be greatly hastened.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The rush of work in the steel-making establishments goes on apace, every available source of labour being tapped to its utmost capacity and every endeavour being made to round up the greatest possible output of war material. Indeed, to such an extent is this being accomplished that practically no attention is given to any other class of work, and with it all even the present high rate of production does not satisfy the demands of the Government. Shell-steel bars are a heavy item, and enormous quantities are being produced, as well as an extraordinary supply of the varied requirements necessary for the proper pursuit of the war. Shipbuilding sections, ship plates and angles are also greatly in demand in consequence of the heavy responsibility which has been accepted by Clyde shipbuilders for the extensive construction both of naval and mercantile shipping. This means working at the highest possible tension for many months ahead. Prices are still quoted similar to a week ago—ship plates, 14*l.* 5*s.* per ton or thereabouts; boiler plates, 15*l.* 5*s.*; and angles, 14*l.*

Malleable Iron Trade.—Strenuous conditions continue to prevail in the malleable iron trade, makers finding the demand for their iron and steel products so heavy that they must strain every effort to cope with the orders on their books. Great effort is being made to keep pace with the demand for material required for war purposes, more of which will now be available, since the restriction on the export of iron has come into force. In addition to this, the necessity of procuring a licence for the shipment of iron will further curtail the already rapidly diminishing export trade. At the moment the only outputs going away are against home orders. Prices are much on a level with those of last week.

Scotch Pig-Iron Trade.—As has now been the case for some considerable time, the steel and iron works doing Government contracts have first claim on the pig-iron output, and but little is left for the ordinary consumer after these demands have been met—at least, through the customary channels. The continued abnormal demand for hematite grades at the steel works has made for a slight, though only temporary, scarcity. Forge quality, also, of which enormous quantities are being absorbed by the iron works, is none too plentiful, despite the additional sources of production. No change in price has taken place during the week.

Glasgow Engineers and the Trade Card Scheme.—The members of the Amalgamated Society of Engineers employed in the Glasgow district held a meeting in the city a few days ago, to consider the reports submitted by their representatives to the recent delegates' meeting. A very animated discussion took place in connection with the desire of the delegates' meeting that the trade card scheme of military exemptions be abolished, a discussion which was taken part in by many of the district officials. Eventually a resolution disapproving of the report of the delegates was moved and seconded, which, there being no amendment, became the finding of the meeting. Following this meeting the district committee met to consider the next steps to be taken in the matter.

The Government and Holidays.—Much satisfaction is being expressed over the fact that, if nothing untoward happens, the Glasgow Fair Holidays will take place as usual in the middle of July, with the full approval of Government. Now that the matter is definitely fixed it will be a case of the greatest possible activity from this time onwards, and without doubt everyone will work better and steadier with the prospect of a ten or twelve days' break in less than a couple of months. Last year's action, necessary as it was, caused much upset, inconvenience, discontent and outlay, and a repetition would be undesirable in the extreme.

AMERICAN WOODEN SHIPS.—We read in *The Iron Age* that the United States Government has awarded to the Foundation Company, New York city, the contract for building an indefinite number of wooden ships, which will be part of the fleet that will be used in carrying food, munitions and supplies to the entente Allies. Work will be started immediately in building a plant near the city of New York; the plant will occupy 55 acres, with 1,500 ft. water-front. It will be under the supervision of the Government and under Government guard. The ships will be of 3,000 gross tons and will cost about 350,000 dols. each. The company is also investigating as to the possibility of establishing a plant on the Pacific Coast for the building of vessels for the Government.

TIMBER SAVING.—The attention of the Board of Trade has been drawn by the Director of Timber Supplies to the large quantity of wood which is consumed in the manufacture of packing cases intended for the transport of goods both in the home and export trade. They wish to point out that, in view of the necessity of restricting imports and at the same time of supplying essential war requirements, it is absolutely necessary to observe the strictest economy in the use of wood. Great assistance could be rendered by traders if the use of wooden packing cases and crates were abandoned altogether, or, where this is not possible, if crates were substituted for packing cases. The Board of Trade have had under consideration the issue of an absolute prohibition on the export, except under licence, of wooden packing cases containing goods, but they hope that the response of the trading community to the appeal for economy in the use of wood will prove so satisfactory that the necessity for taking this step may be avoided.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—For the first time for many months there has not been anything like an excess of demand over supply in the steam coal market. This has been due to artificial conditions, arising out of the labour troubles in the engineering world. The present inquiry in the market shows that works are commencing to run more nearly on normal lines, and those concerns which have taken advantage of the temporary slackness to buy up reserves have placed themselves in a very comfortable position. The tonnage of larger sorts which comes into the city is not on a very large scale, but there are prospects that improved railway workings, which have been promised to local industrial undertakings, will soon place a different aspect on the situation. Collieries are said to be restricted in their activities by want of transport facilities, and when these are remedied there should be a more regular and enlarged output. Smaller sorts are in much the same condition as the others, though gas nuts are not yet arriving in sufficiently large quantities. The export inquiry for the whole of these grades is nothing like so insistent as at the beginning of the year, and the falling-off has tended to relieve the home congestion. Householders are evidently following the advice given to them in the House of Commons, for dealers and depots declare orders are coming to hand almost at the rate of winter trade. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at the pit.

Iron and Steel.—Labour troubles, to which we give special reference elsewhere in these notes, have affected the output of steel during the last few days, but it is now hoped, with the dispute at an end, something will be done to make amends. We understand that the men are not averse to working with redoubled energy, and putting in extra time, but they will have to be given a strong lead from those in authority. Whether this will be forthcoming we are not in a position to say at the time of writing. The demand for all grades of steel has increased rather than fallen on the week, and it will take some time to fulfil all the orders on the books. Large contracts have been placed here by the big firms farther north for all classes of shipbuilding material and tools, and the makers of high-speed steel cutting tools have more on hand than they can deal with for some time ahead. This is in a measure due to the practice of customers in placing indents for future needs in time to have their requirements completed when the articles will be most wanted, and not to any falling-off in Sheffield's capacity for producing this particular type of tool. One satisfactory feature should be here noted, and that is the quality of the tools which Sheffield firms have supplied has given entire satisfaction; the tools have proved far superior in cutting power to anything else yet placed on the market by outside concerns, whether friendly overseas competitors or otherwise. The raw material position is one of general tightness, with makers of common irons holding back in the hope that the much-looked-for advance in prices will be speedily announced. The view held in this district is that they are indulging in vain hopes, for firms have been informed that nothing will be done which will have the effect of increasing their expenditure in the production of war material. In fact, from the various reports from the different Government departments directly interested, there seems a tendency the other way round, viz., to give firms every possible opportunity to work with the utmost economy. High-speed steel makers will very likely confirm this, for they are meeting with but small encouragement in their agitation for a higher tariff than the present 2*s.* 10*d.* and 3*s.* 10*d.* per pound for 14 per cent. and 18 per cent. tungsten high-speed steel. The Government have replied that the situation does not warrant any advance, especially when it is remembered to what lengths the authorities have gone in financing the delivery of supplies of ores from overseas and ensuring the regular arrival of alloys for the benefit of the trade. Agricultural engineers have got to the height of their busy season, and overtime is being consistently worked. It is pleasing to report that farmers generally are helping the manufacturers by placing their orders early, and this facilitates output. Cutlery makers, and plate workers, are engaged principally with War Office and export work. The latest overseas trade of a general character includes indents for files, saws, hammers, tools, wirework, hardware, knives, bolts and nuts, bill-hooks, springs, cutlery and plate.

The Labour Dispute.—There seems little doubt that the strike originated through a misunderstanding on the part of the men, who neglected to be advised by their recognised leaders. The dramatic arrest of two of the Sheffield men added a little fuel to the fire, but this week there has been an almost universal return to work, despite the decision of a mass meeting on Monday that there should be no return until it was made clear what action the Government would take with regard to the arrested leaders. One fact is clear, and that is the major portion of the men have had enough of striking for some time to come. They have failed to gain popular sympathy, and have also found other unions display a hostile attitude to them for their unpatriotic conduct.

The Parkgate Iron Company.—In their annual report just issued the directors of the Parkgate Iron and Steel Company, Limited, state that the profit for the year, after making provision for taxation and depreciation, is 103,969*l.* 3*s.*, while 5,399*l.* 15*s.* 10*d.* was brought forward from last year, making a total of 109,368*l.* 18*s.* 10*d.* It is proposed to pay a further dividend, making the total for the year at the rate of 15 per cent. The output of steel has exceeded that of any year since the company was formed. With the consent of the Ministry of Munitions the company has undertaken to extend the works very considerably, involving large additional capital expenditure, and for this purpose a further 40,000*l.* has been placed to reserve instead of paying a higher dividend. The capital of the company will also be increased by the creation of 100,000 new 1*l.* shares. In addition to all this, 144 acres of land adjoining the works have been acquired.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The market shows no new feature of moment. The output of Cleveland pig-iron is going rapidly into consumption under the May allocations, which are now running out. June allotments are being considered, and it is expected they will commence to be issued on a liberal scale next week, as there is no dearth of pig-iron. Shipments of Cleveland pig-iron show improvement, but they are still much below what could be wished. Quotations are firmly adhered to. For home consumption No. 3, No. 4 foundry and No. 4 forge are all quoted 92*s.* 6*d.*, and No. 1 is 96*s.* 6*d.*; whilst for shipment to France and to Italy No. 3 is 102*s.* 6*d.*; No. 4 foundry, 101*s.* 6*d.*; No. 4 forge, 100*s.* 6*d.*; and No. 1, 107*s.* 6*d.*

Stocks of Cleveland Pig-Iron.—Makers as well as consumers have little opportunity to accumulate stocks of pig-iron, and the quantities at their yards are understood to be very small. So far this month only one change has been made in the stock of Cleveland pig-iron in the public warrant stores, a withdrawal of 118 tons of No. 3 having been recorded on the 10th. Only 1,879 tons remain in the warrant stores, 6 tons being iron deliverable as standard and 1,873 tons No. 3 quality.

Hematite Iron.—The demand for East Coast hematite iron is heavy. Under strict official supervision, the legitimate needs of home consumers are being adequately met, but the surplus available for export is small. A moderate trade is passing on home account, but new export business is very limited. Sellers are more reluctant than ever to accept the recognised market rates for despatch to customers abroad, and export quotations are nominal. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Foreign Ore.—Supplies of foreign ore coming forward must be considered as on a fairly good scale, and they are allocated by the local control committee, in a manner which, under the conditions prevailing, may be said to be satisfactory.

Coke.—As is usually the case just before the Whitsuntide holidays, there is an enhanced demand for coke for the blast-furnaces, but supply is very plentiful, and adequate deliveries are being effected. Descriptions needed continue to command fixed maximum prices. Average blast-furnace kinds are 28*s.* at the ovens, and qualities low in phosphorus are 30*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—Pressure for delivery of manufactured iron and steel is unabated. Producers are, however, able to go a long way towards satisfying the huge Government requirements and the large needs of the shipyards. To home customers common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 18*l.*; steel bars (no test), 14*l.* 10*s.*; steel ship-plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.* and upward; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

New Director of Messrs. Scott Brothers, Limited.—Mr. Thomas Mackendrick has been appointed a director of Messrs. Scott Brothers, Limited, iron merchants, &c., whose head offices are at Newcastle-on-Tyne, and who have branches at Middlesbrough, Hull, and Liverpool. Mr. Mackendrick has for a number of years been the manager of the company's Middlesbrough branch.

SHIPBUILDING IN JAPAN.—We read in *The London and China Telegraph* that a large extension of equipment is projected by the Mitsubishi Dockyard and Engine Works at Kobé. This company is to build four steamers this year, ranging from 2,000 tons to 6,000 tons, while the construction of other vessels on its own account is also contemplated. To meet the increased demand for building capacity, the management has undertaken the construction of two new docks, and a new floating dock of 20,000 tons lifting capacity. It is said that when these projects are completed the Mitsubishi yard in Kobé will be able to build ships aggregating 60,000 tons a year. The new floating dock will be moored in the new basin as soon as the breakwater of about 1,000 ft. is completed. This breakwater will run from the end of Wada Point, nearly parallel with the existing inner breakwater of about the same length. A new engine shop is now being constructed with the intention of manufacturing Diesel engines for land and marine purposes, especially for submarine boats, together with petrol engines for aeroplanes, motor boats and motor cars. The new shop is expected to be finished by about the middle of this year. It has also been decided to commence the manufacture of the "Stal" type of steam turbine.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Comparatively very little business has been transacted on the Cardiff coal market this week. It is anticipated that the Admiralty return will show a further reduction in the number of ships lost, but arrivals are not increasing and many collieries are in sore need of empties. For spot positions prices therefore were easy, but for next week's deliveries a firmer tone pervaded the market, and sellers are hopeful that the position will be further strengthened as the result of the Whitsun holidays. Meanwhile current quotations are approximately what they were last week.

Newport.—There has been very little material change in the position of Newport coals this week. It is expected that next week's reduced outputs will react favourably on prices, particularly as the workmen are determined to take three instead of two days' holidays; but for spot shipments prices have been easy at last figures. There is no improvement in the pitwood position.

Pitwood for the Collieries.—The situation in the pitwood import trade of the Bristol Channel has been growing worse from day to day, and unless authoritative measures are adopted immediately by the Government departments concerned many pits in the coalfield may have to stop work. Towards the end of last week the Customs authorities revived the practice of withholding permission for the despatch of imported wood from the dockside to the collieries till certain formalities had been complied with, and the result was that consignments which ought to have been distributed were held up for several days. A hurried meeting of the Bristol Channel Pitwood Importers' Association was held at the Cardiff Exchange, and later on the same day at a meeting of the Welsh Coalowners it was decided to communicate with the Prime Minister on the general question of the supply of pitwood to the collieries.

Miners' Holidays.—The Controller of Mines sent a telegram to the Welsh Coal Board this week asking that the Whitsun holidays be curtailed to two days. The workmen's side of the Board, however, declined to fall in with the Controller's suggestion in view of "the tremendous amount of stoppages" now experienced in the coalfield. They, therefore, decided that three days' holidays be taken as usual.

TRADE OF NEW SOUTH WALES.—The oversea imports during January were valued at 3,410,621*l.*, and show an increase of 883,740*l.*, or nearly 35 per cent., as compared with the corresponding month of last year. The total for seven months, July to January, 1916–17, was 21,887,660*l.*, an increase of 2,730,142*l.*, or 14.2 per cent., in comparison with the figures for 1915–16. The oversea exports during January amounted to 3,051,917*l.*, being an increase of 649,884*l.*, or over 27 per cent., as compared with the corresponding month of last year. For the seven months, July to January, there was a decrease of 2,750,507*l.*, or 10.8 per cent., compared with the same period for 1915–16.

COST OF MAINTENANCE OF LOCOMOTIVES.—We read in *Engineering News-Record*, New York, that electric locomotives on the Norfolk and Western Railway, according to that company's report for the six months ended December 31, 1916, have proved much more expensive to maintain and operate than steam locomotives. The average cost of repairs, power and lubricants for electric locomotive equipment, per 100 locomotive-miles, was 62.90 dols., while that of repairs, fuel, stores and lubricants for steam locomotive equipment was only 25.21 dols. Repairs were respectively 32.69 dols. and 12.70 dols. Power and lubricants for the electric locomotives cost 30.21 dols. per 100 locomotive-miles, as against 12.51 dols. for fuel, stores and lubricants for steam locomotives.

CHEMICAL REACTIONS IN A STEAM BOILER.—Mr. G. L. Fowler has made some most interesting experiments on the water in a steam boiler, and has published them in *The Railway Gazette* of May 4. In a small boiler 75 gallons of water were reduced by evaporation at 200 lb. pressure to 1 gallon, analyses being made before and after. The changes which took place were quite unexpected, as shown by the subjoined table:—

	Grains per Gallon.	
	Raw Water.	Concentrated Water from Boiler.
Calcium carbonate ...	1.34	0.73
Calcium sulphate	—	1.91
Magnesium carbonate ...	0.70	—
Magnesium sulphate ...	0.17	2.76
Magnesium chloride ...	—	1.74
Sodium sulphate	0.52	—
Sodium chloride	0.70	2.11
Sodium nitrate	0.07	0.57
Silica	0.58	5.47
Alumina and iron oxide ...	0.29	2.64
Organic matter	0.81	2.29
	5.18	20.24

The raw water contained neither calcium sulphate nor magnesium chloride, and yet both were found in the water taken from the boiler. On the other hand, sodium sulphate and magnesium carbonate disappeared. The calcium sulphate was probably formed by the decomposition of the sodium sulphate and the passage of the sulphuric acid over to the lime; while the magnesium chloride was probably formed by the decomposition of the salt in the presence of organic matter and the taking out of chloride by the magnesium.

THE KING'S VISIT TO MUNITION FACTORIES.

(*For Description, see Page* 492.)

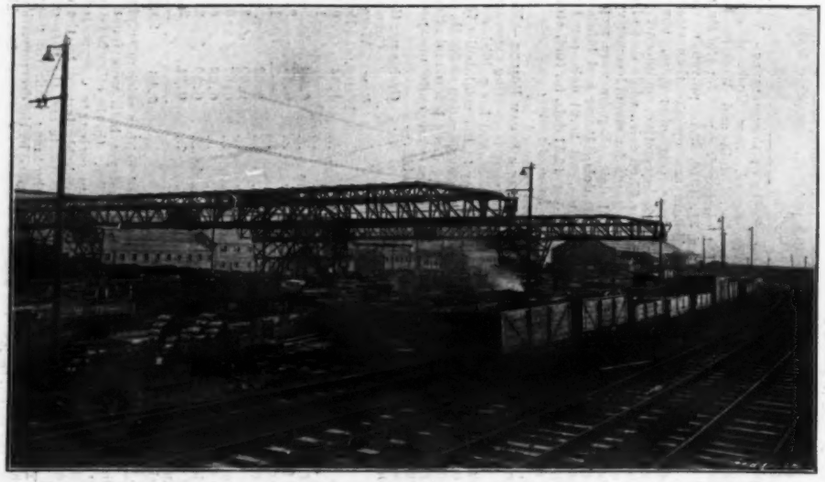


FIG. 11. VIEW OF STOCKYARD AND TRANSPORTERS, NATIONAL PROJECTILE FACTORY.

FIG. 13. MACHINING 6-IN. SHELL HEADS.

FIG. 12. FORGING 9.2-IN. SHELLS.

FIG. 14. PRESSING ON 9.2-IN. COPPER BANDS.

THE ROYAL VISIT TO MUNITION FACTORIES.

(*For Description, see Page* 492.)

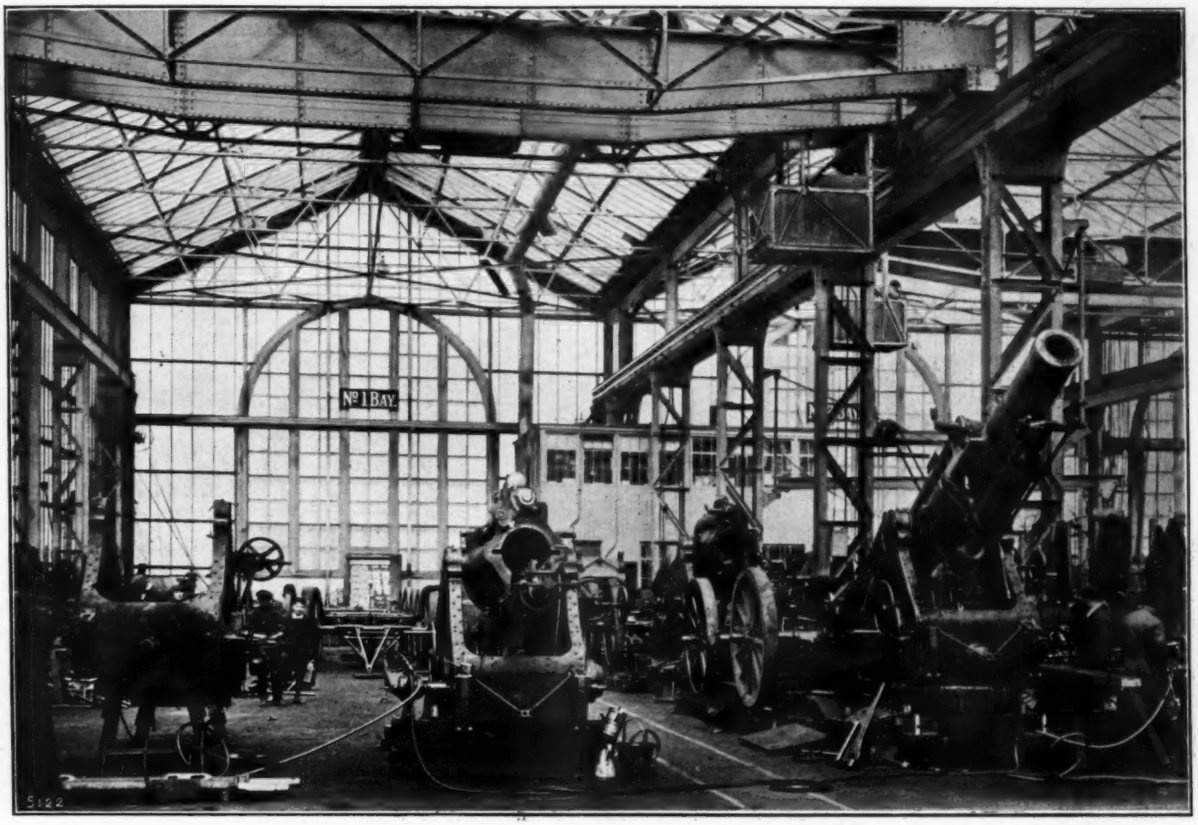


FIG. 1. NEW HOWITZER SHOP AT VICKERS' WORKS; INTERIOR OF NO. 1 BAY.

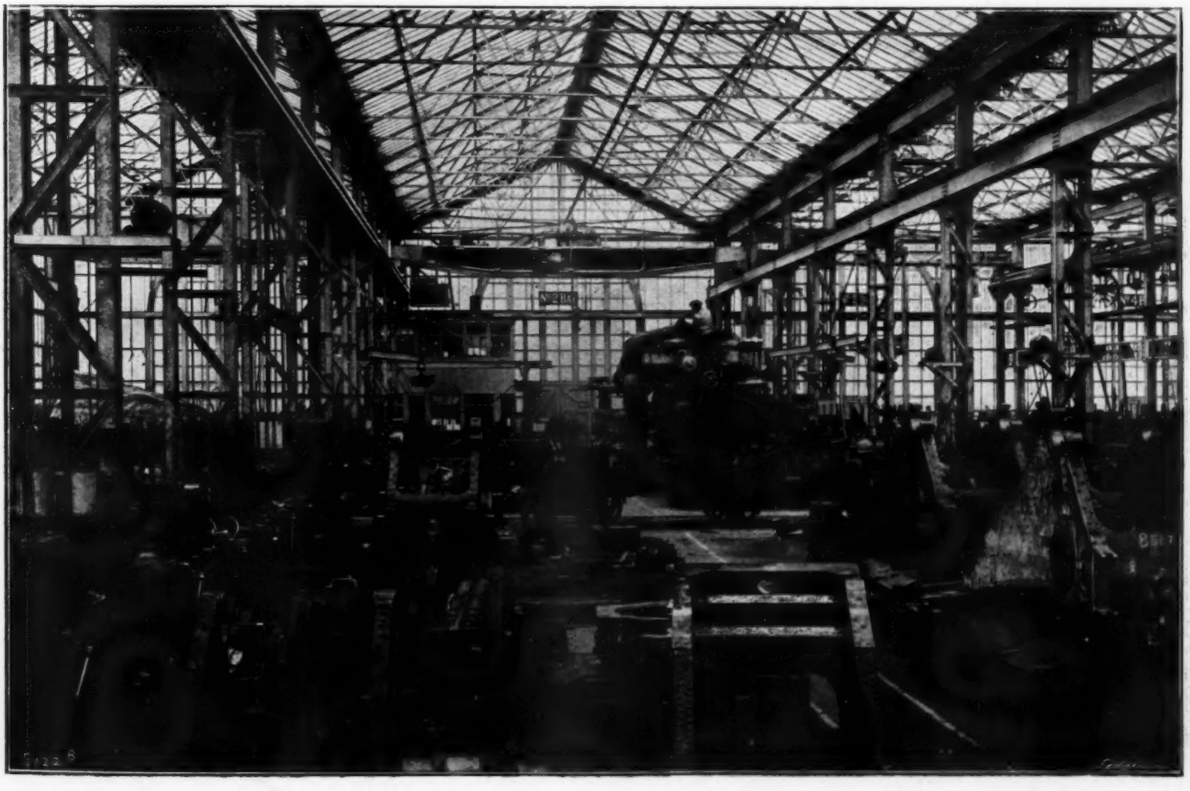


FIG. 2. NEW HOWITZER SHOP AT VICKERS' WORKS; INTERIOR OF NO. 2 BAY.

(*To face page* 492.)

THE ROYAL VISIT TO MUNITION FACTORIES.

(*For Description, see Page* 492.)

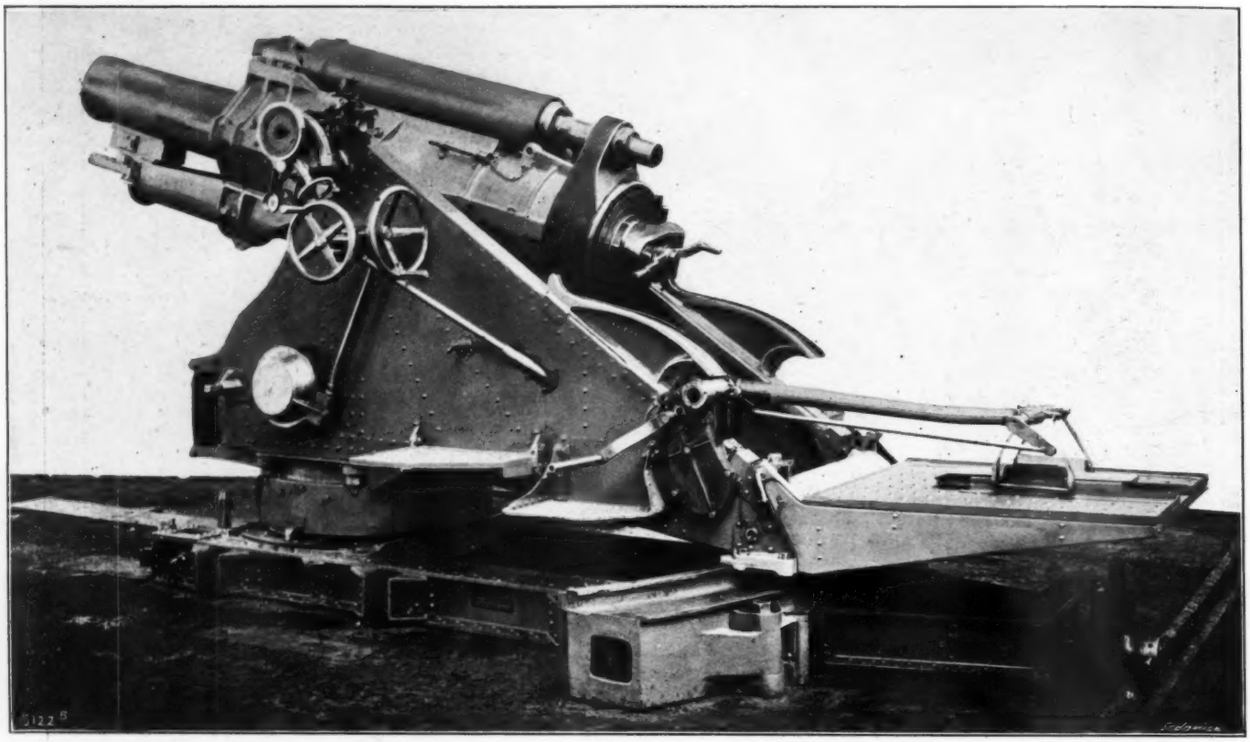


Fig. 3. 9.2-In. Howitzer on Siege Mounting.

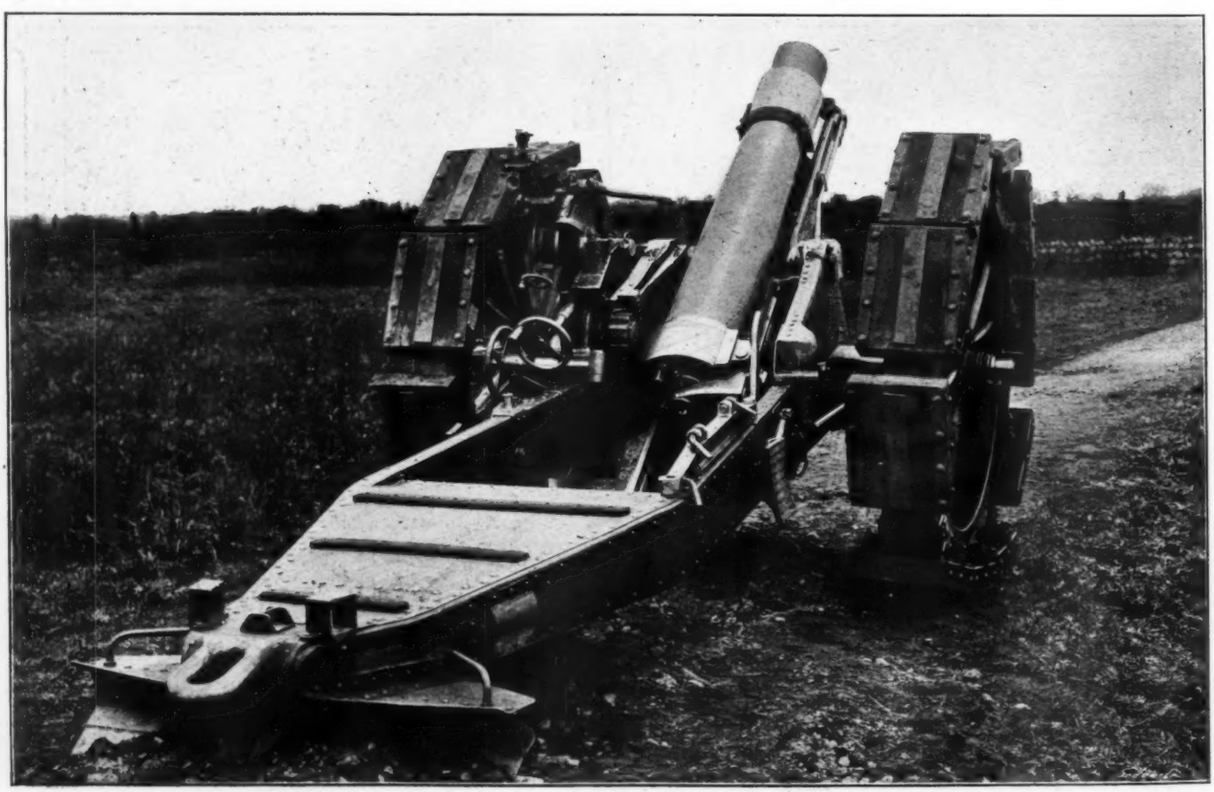


Fig. 4. 6-In. British Howitzer.

THE ROYAL VISIT TO MUNITION FACTORIES.

(*For Description, see Page* 492.)

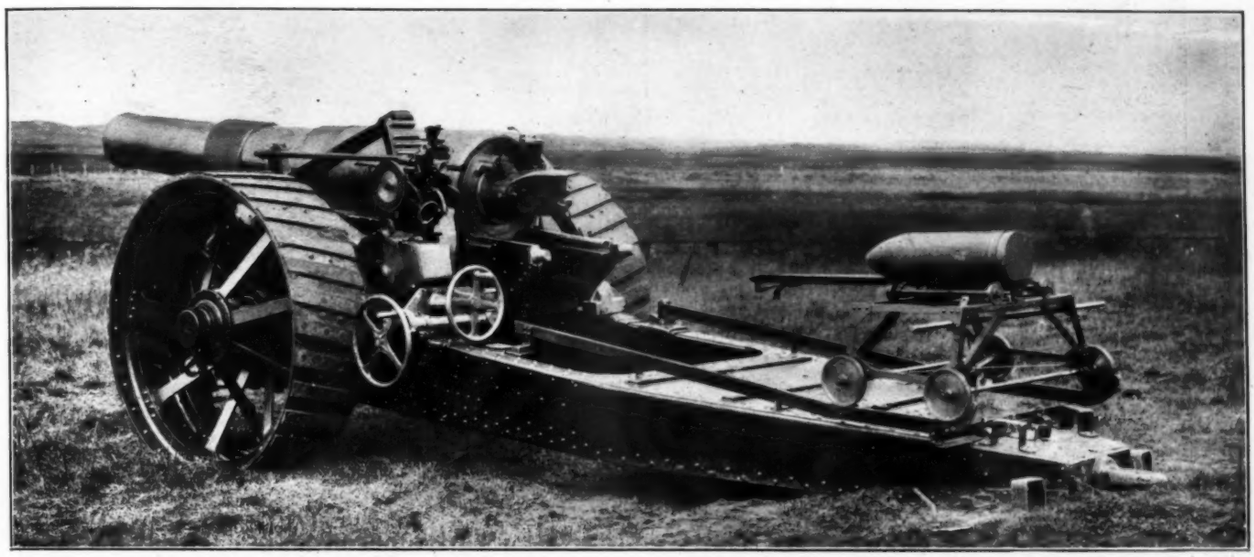


Fig. 5. 9.2-In. Field Howitzer.

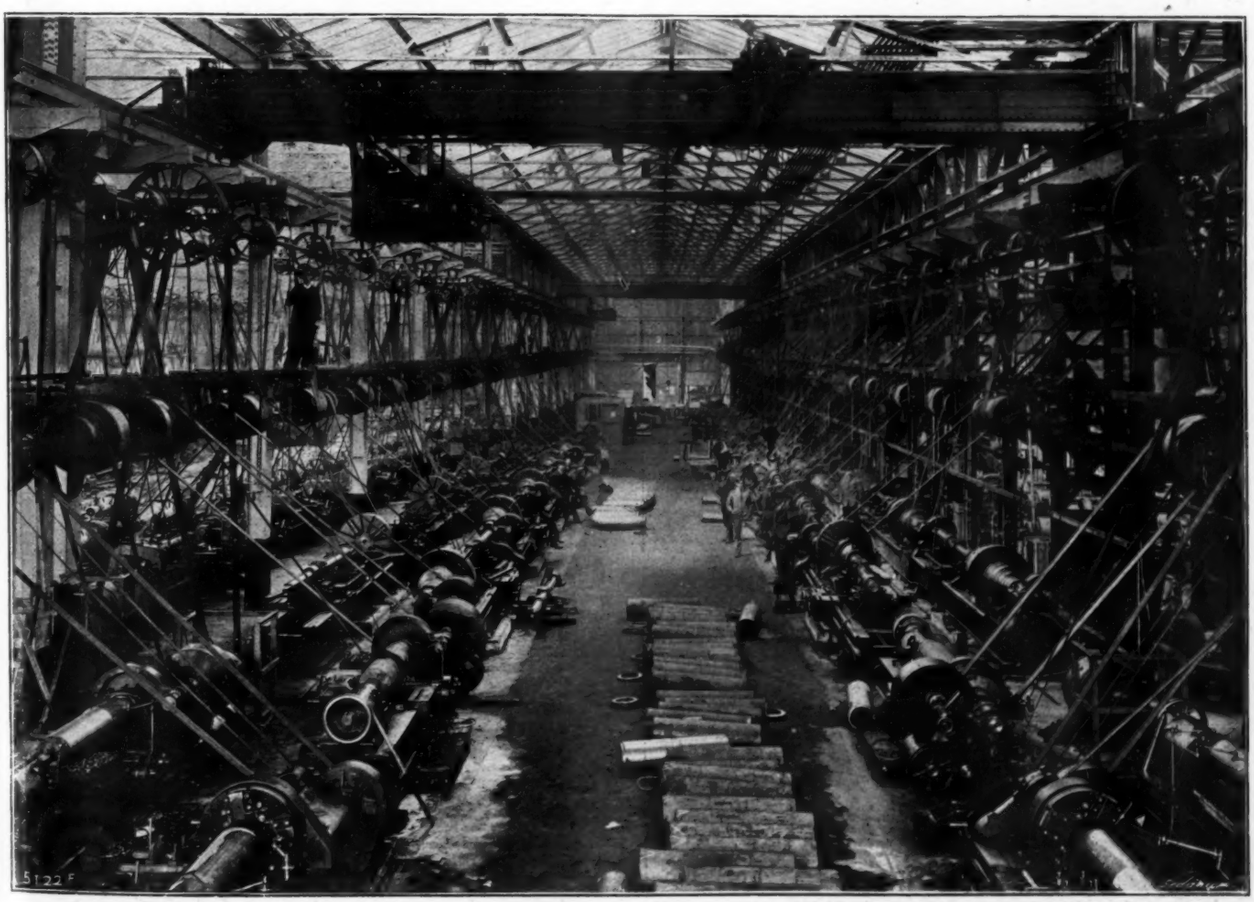


Fig. 6. No. 3 Bay. Machine Shop for High Explosive Shells at Vickers' Works.

THE ROYAL VISIT TO MUNITION FACTORIES.

(*For Description, see Page* 492.)

FIG. 7. SHOP FOR 3-IN. SHELL AT VICKERS' WORKS.

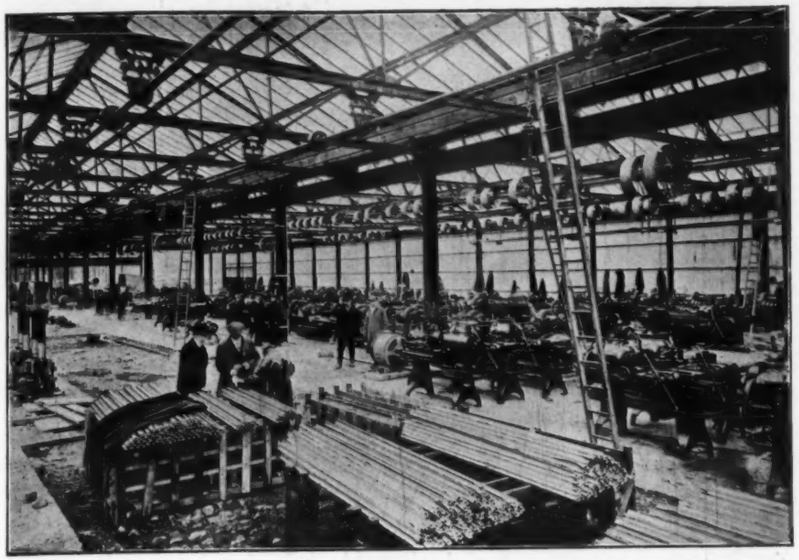


FIG. 8. 60-POUNDER MACHINE BAYS, NATIONAL PROJECTILE FACTORY, FEBRUARY 17, 1916.

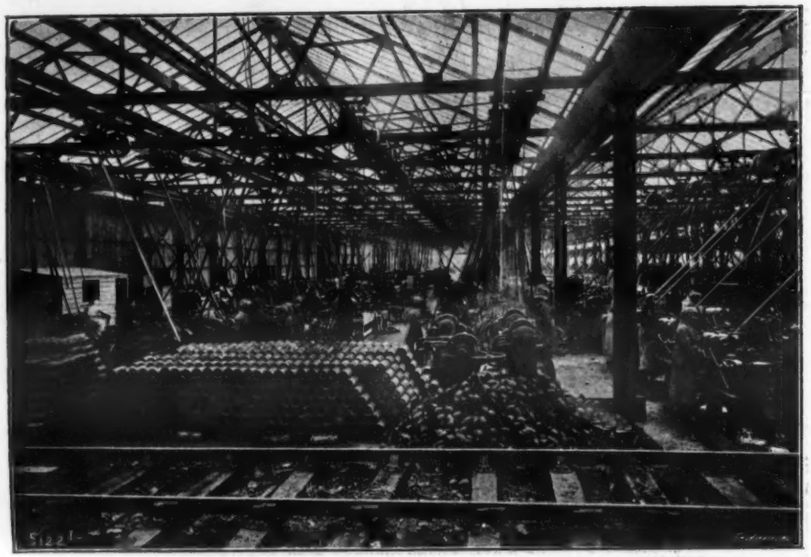


FIG. 9. 60-POUNDER MACHINE BAYS, NATIONAL PROJECTILE FACTORY, MARCH 24, 1916.

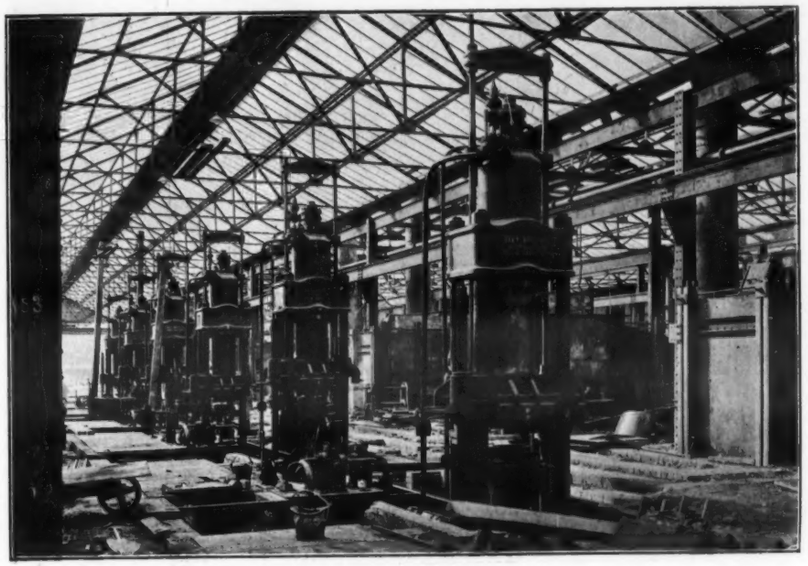


FIG. 10. 60-POUNDER PRESSES, NATIONAL PROJECTILE FACTORY, MAY 31, 1916.

(*To face page* 493.)

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia, Melville and Mullen, Melbourne, Victoria.
CANADA, Toronto, Ont.: Wm. Dawson and Sons, Manning Chambers. Montreal: Sells, Limited, 203, Shaughnessy Building, McGill-street.
EDINBURGH: John Menzies and Co., 12 Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Subscriptions and Advertisements, Librarie B. Tignol, 53bis, Quai des Grands-Augustins, Paris. Also for Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan, and any post-office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Longstreet.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. Chicago: H. V. Holmes, 957-958, Monadnock Block.
For Advertisements, J. S. Allan, 508, Stratford Avenue, Bridgeport, Conn., U.S.A.

ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£2 4 6
For Canada—	
Thin paper copies	£2 0 6
Thick " "	£2 5 0
For all other places abroad—	
Thin paper copies	£2 5 0
Thick " "	£2 9 6

When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.
Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.
All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8508 GERRARD.

CONTENTS.

	PAGE		PAGE
The Institution of Mechanical Engineers	491	Notes from South Yorkshire	499
The Royal Visit to Munition Factories (*Illus.*)	492	Notes from Cleveland and the Northern Counties	499
The Metric System	494	Notes from the South-West	499
"The Electrical Properties of Gases"	495	Men and Skilled Men	501
Draughtsmen and Foremen	496	The Complexity of Chemical Elements (*Illus.*)	502
The Raymond Concrete Pile (*Illus.*)	496	The Electrical Properties of Gases	503
The Supply of Electric Power	496	Notes	505
The Prestwich Fluid Gauge (*Illus.*)	497	The late Sir Alexander Richardson Binnie (*With Portrait*)	506
The Physical Society of London	497	Industrial Notes	507
Colonial and Foreign Engineering Projects	498	Capital and Labour in Co-operation	508
Notes from the North	498	Notes on the Construction of Turbine Pumps (*Illus.*)	508

With Four One-Page Plates of the ROYAL VISIT TO MUNITION FACTORIES.

NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, May 25, at 5 p.m., at the Imperial College of Science, Imperial Institute Road, South Kensington, S.W. Agenda:—(1) "An Investigation of Radium Luminous Compound," by Mr. C. C. Paterson, Mr. J. W. T. Walsh and Mr. W. F. Higgins. (2) "The Resistance to the Motion of a Lamina, Cylinder or Sphere in a Rarefied Gas," by Mr. F. J. W. Whipple. (3) "The Effect of Stretching on the Thermal and Electrical Conductivities of Wires," by Dr. C. H. Lees, D.Sc., F.R.S.
THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, May 25, at 8 p.m., at the Institution offices, 39, Victoria Street, Westminster, W.C. Dr. William Wilson, F.R.S., will exhibit and describe a tellurion. The meeting will be held in the new offices, to which this occasion will be a sort of "house-warming."
THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, June 1, at 5.30 p.m. A discourse will be delivered by Mr. J. H. Balfour Browne, K.C., D.L., J.P., LL.D. The subject is the "The Brontës: a Hundred Years After." Afternoon lectures next week at 3 p.m. Tuesday, May 29. Professor W. W. Watts, LL.D., Sc.D., F.R.S., on "The Flow of Ice and of Rock—the Movement of Glaciers" (Lecture I). (The Tyndall Lectures.) Thursday, May 31. Mr. Arthur C. Benson, C.V.O., LL.D., on "The Art of the Essayist" (Lecture I). Saturday, June 2. Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Pres.R.S., Professor of Natural Philosophy, Royal Institution, on "The Electrical Properties of Gases" (Lecture V).

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

ENGINEERING.

FRIDAY, MAY 25, 1917.

MEN AND SKILLED MEN.

IN administering the revised man-power scheme that came into operation last week the authorities will need to exercise an inflexible impartiality. They will be beset with temptations to use their powers, not for the exclusively national purpose for which they were given, but to propitiate the skilled minorities that are represented so strongly in and round the Government. If they yield to the temptation they will expose the skilled man to the reproach of using his skill as a screen against the sacrifices and dangers that other men are undertaking. Innately a lover of fair play when he is left to himself, the skilled man will not thank his friends in the long run for the discreditable immunity; and in the meantime the yield of man-power from the skilled trades will be impaired to whatever extent replaceable skilled men have been retained.

The new system has certainly removed one ground on which this complaint has been often and justly made. It has removed the glaring anomaly of trade-card exemptions. No blame can attach to trade unions for having accepted the advantage that they derived from the system which has at last expired; but it was a system that involved unsound distinctions between men, turning on quite other considerations than those which alone should have been taken into account. As was pointed out in the official statement issued at the time, it gave members of one union an advantage over members of other unions; but a still more glaring anomaly was that it put members of no union at a disadvantage as against privileged unionists. This is not the time or place to discuss the politics of the organisation of industry; but it is equally little a time when a Government, which should hold an even balance between all honest workers who do their best, should by a side-wind have given a conspicuous advantage to the groups who are represented by the unions, and have put a premium on membership of those bodies quite independent of the merits of their organisations. The future of the trade union movement is not likely, and ought not, to benefit by the accretions of membership that have come to it in this way; and in the interests alike of the unions and of the industries on which they live, it is to be hoped that the expiring trade-card system may be the last instance of indirect coercion by which men are pressed into the union ranks for any reason except a genuine belief in union principles.—*Engineering.*

The abandonment of the trade-card system is, however, no guarantee in itself that the Government has at last determined to treat all workers alike, and to abolish privileges that not only do not help the country, but actually withdraw help from it. Nor, unfortunately, is it possible to detect any such intention in its recent declarations. The position, as stated quite plainly by the Government, is that men are wanted outside the engineering industries for work that only men can do; and the most fruitful means of obtaining them is to substitute women for men on those jobs that women can do. By the experience of the last two years it is known that a large part of the present work of skilled and unskilled men can be done by women at least as efficiently and rapidly as men have been doing it. We are here using the word "skilled" in the trade union sense. As we stated in a recent article, the really skilled mechanic, such as was the old millwright, is somewhat rare, and represents not only long experience, but also innate mechanical ability. He cannot be created by a few weeks or months of instruction, and it would be mistaken policy to put him to work at which his skill and knowledge would find no proper outlet. He cannot be replaced by a woman who has not had at least an equal experience, but there are plenty of men in the engineering trades who are doing work—whatever may be their skill—which can be done equally well by women, and who therefore could be replaced. Any influences which impede this replacement prolong the war; and the price of such impediments is paid not only in money, but in the precious lives of men at the front.

The country has an honourable engagement with its forces to neglect nothing by which their sacrifices may be economised. The engagement has not been negotiated with a Soldiers' or Sailors' Union, reduced to writing, or handed over to lawyers to construe; but it is, nevertheless, the most solemn of the obligations that bind the nation and every part of it, and individual workmen, skilled or unskilled, would not knowingly be parties to repudiating or tampering with it. Yet, if the Government's declaration is to be read literally, the extent to which skilled men are to be withdrawn from any trade for national service is not to be determined merely by the consideration of whether they can be replaced sufficiently by women, but by the quite other test of whether unskilled men remain engaged in the trade. Leaving out of account altogether the respective rights of skilled and unskilled men, to apply such a criterion is to repudiate the country's obligation to do its best for its soldiers. The only effect that it can have on the yield of men for national service is to keep men on work that women could do, and to reduce the country's effective forces by the number of men so kept.

Though the workmen would feel their rights to be of less consequence and concern even to themselves than the lives of their soldier and sailor comrades, they are none the less considerable. The skilled man may feel it hard that he should be taken for military service, and his job given to an unskilled man who could have gone to the wars as well as he could. By the same token an unskilled man may see nothing in his comrade's superior skill and better pay to justify the Government in asking the poorer man to make the greater sacrifice. No one can belittle these hardships, or withhold sympathy from any measures by which those who leave their civil work to join the military forces may be assured of their job when they come back. The more fairly and impartially the choice of men for service is made, the more assured will be their restoration to their old position; for it will be backed by the obligations of fair play, which, when they are felt by a convinced public opinion, are worth more than agreements. Men, for instance, would gravely weaken their claim on the co-operation of their fellow-citizens if they continued to insist that in staple industries not essential to the war their places should not be filled by women while they were

(To face page 493.)

away, and the industries so kept on foot for the ultimate benefit of all who were concerned in the trade. It would be a dog-in-the-manger policy; and though a responsible Government could hardly allow it to be successful, it would do harm to the ultimate interests of the workmen on whose behalf it was supposed to be put forward, and therefore to those of the industry and the nation, which are inseparable from the well-being of all classes of their citizens and men.

But though these considerations have to be taken into account, and would be of the highest consequence in any circumstances less tremendous than those in which the nation is living, the outstanding need in the administration of the man-power scheme is the scrupulous observance of the country's obligations to its soldiers, and the impartial distribution of the burdens that it involves, without either fear or favour.

From a strictly economic point of view it is bad policy to expose men of special skill and ability to war risks unless their aptitudes are of a military character. But such considerations are inoperative in a democracy. The danger of defeat menaces the entire nation, and all must take their share in repelling it regardless of the necessities which will arise after the advent of peace. We stand or fall as a community, and the responsibility lies evenly on all shoulders that are strong enough to carry the burden.

Engineers have, therefore, no claim to be treated as a privileged class. Their technical skill is doubtless part of their own and the nation's wealth, as many other qualities are, such as character, knowledge and inventive ability; but it gives no greater right than any other form of wealth to exempt its possessor from doing his duty to the nation. The only test that can properly be applied is whether the man can serve his country better in the shops than in the field. To demand that skilled men should not be recruited for military service, however fully women can fill their places, until all unskilled men had been exhausted would be an attempt to withhold from our forces help that could be given them, and to give skilled men an unfair and invidious privilege over their unskilled comrades and the nation's manhood at large. It would stigmatise the skilled engineer, and attract to him an odium that, left to himself, he would be as little likely as any man to deserve or incur.

THE COMPLEXITY OF THE CHEMICAL ELEMENTS.

THE chemist has reason to complain that the atoms of the physicists of our days may explain radiation and electromagnetic phenomena, but do not tell him how to understand chemical affinity and the vast variety of reactions. Though the problems of theoretical chemistry are largely those of physical chemistry, the chemist and physicist pursue each his own line of research, each sufficiently difficult, and it may still be said that physicists and chemists often do not understand one another. When Professor P. Langevin, on March 23, delivered the Guthrie lecture on "Molecular Orientation" before the Physical Society, he confined himself almost to magnetism and radiation; and when, a week later, Professor A. Scott delivered his address as retiring president to the Chemical Society on "The Atomic Theory," he dwelt chiefly on the work of Stas and on Prout's hypothesis and the exact quantitative basis of the periodic law, without referring to modern speculations as to the structure of the atom. In his Royal Institution discourse of last Friday, the 18th inst., on "The Complexity of the Atom," Professor F. Soddy, F.R.S., of Aberdeen, really approached the problem from the standpoints of both the chemist and physicist, with all the acumen and boldness that one expects from one of the originators of the theory of radioactive disintegration. It was a very remarkable discourse, which deserves the fullest attention.

The elements of the chemist, Professor Soddy said, were known to be complex in three senses. In the first sense the complexity concerned the general nature of matter and followed from the general relations between matter and electricity developed during the past century. Except in very special phenomena, neither free electricity nor free matter could be studied alone. The "free elements" of the chemist were no more free than they were in their compounds; in compounds the elements were combined with other elements, in the so-called free state they were chemically combined with electricity. That was fairly well understood in principle, but consistent detailed application of the principle to the study of chemical character was still lacking. The complexity in the second sense had startlingly developed from the recognition of radioactive changes and of radio-elements, non-separable by chemical means. The natural corollary was that the elements represented rather a type, the members of the type being alike in most of their properties as studied up till two decades ago, and apparently identical, therefore; but all those properties affected only the outer shell of the atom, and even the deeper-going Röntgen rays did not distinguish between them. A difference was only found in the innermost nucleus, of which radio-activity first made us aware. If the differences were ultimately electrical in character, then the chief criterion of the chemist, the atomic weight determination, would fail to distinguish between different chemical elements. That it had failed, and that there were many more elements than the possible 92 types of the periodic table, Professor Soddy showed subsequently.

In the third sense the complexity of the elements had come down to modern days from the philosophical speculations of the ancients through the alchemists of the Middle Ages and through Prout's hypothesis that all elements were built up from some primordial stuff. Radio-elements, it was now believed, were made up of helium and lead; to make further speculations was for the present probably fruitless. But the existence of isotopes, the experiments on X-rays and the scattering of matter by α particles, &c., gave a definite conception as to what constituted the difference between one element and another. One could see how gold would result from lead or mercury, though one could not control those changes, and Rutherford's nuclear atom, though only a beginning, enormously simplified the correlation of many diverse facts.

Dealing first with the element as a compound between matter and electricity, Professor Soddy remarked that Faraday's law of electrolysis, according to which a monovalent atom carried one charge, the divalent atom two charges, and so on, and his dictum that the forces of chemical affinity and electricity were the same, had really implied, though it was not understood then, the atomic theory of matter and electricity, as Helmholtz had pointed out in his Faraday lecture of 1881 to the Chemical Society. The work of Hittorf on the migration of the ions, the conclusion of Arrhenius that strong salts were dissociated in their solutions, the recognition that many reactions were instantaneous and ionic, and other facts, had familiarised the chemist with the enormous difference between the element in the charged and in the electrically neutral conditions. But the unparallelled intensity of these charges was not sufficiently appreciated; tritely to express it, Professor Soddy stated that the charge on a milligram of hydrogen ions would raise the potential of the world to 100,000 volts, and if one attempted to force free hydrogen ions into a steel bottle, the bottle would burst, by reason of the mutual repulsion of the charges, before the gas forced in would show the spectrum lines of hydrogen in a vacuum bulb. Then had come the fundamental advances as to the nature of electricity, the isolation of the electron or atom of negative electricity by J. J. Thomson, the conception of the ionic character of the discharge through gases, and the reasoning that the electron must possess inertia inversely proportionate to the diameter of the sphere on which it was concentrated, leading to the all-embracing monism that all mass may be of electromagnetic origin. That had put the coping-stone on the conclusion that the elements, as apprehended in ordinary matter, were always compounds. In the "free" state they were compounds of the element in multiple atomic proportions with the electrons. The ions, the real chemically uncombined atoms, could no more exist free in quantity than could the electrons. The compound might be individual, as between atom and electron, or statistical, affecting merely the total number of the opposite charges, and the element would presumably be an insulator or conductor of electricity accordingly. The chemist had long been taught that the hydrogen molecule H_2 and the chlorine molecule Cl_2 had to dissociate into atoms $H - H$ and $Cl - Cl$ before they could unite to $2HCl$; now he should further regard the union as comprising a decomposition or dissociation of the H atom into a positive ion and a negative electron and a combination of the latter with the chlorine atom.

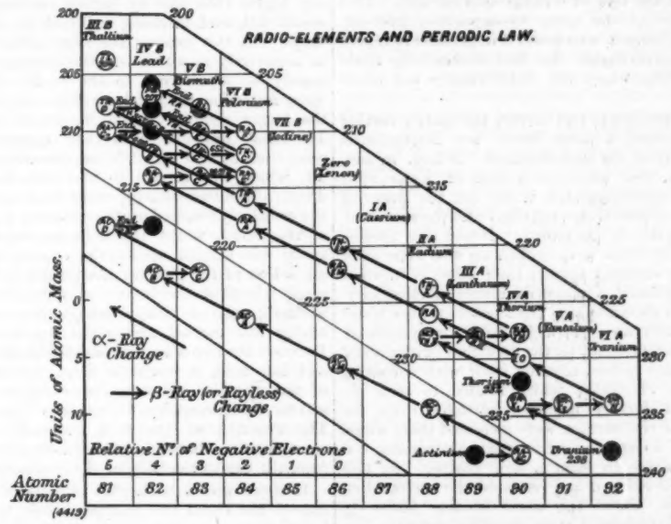
One of the barriers to the understanding of these relations was the conventional idea, derived from electrostatics, that opposite electric charges neutralised one another. In atomic electricity or chemistry the state of neutrality could only apply to a point outside, remote by comparison with the diameter of the atom. We were getting back to the ideas of Berzelius; the atom of hydrogen might be strongly electro-positive and that of chlorine negative, with regard to one another, and yet each electrically neutral in the molar sense. Some day it might be possible to map out the electric fields surrounding each of the 92 types of elements. We had also to face the apparent paradox that the stronger the affinity binding the material and electrical constituents of the atom together, the weaker its combining power; in other words, that the chemical affinity was in inverse ratio to the affinity of the ion for the electrons. The case of helium was instructive; helium did not show any power at all of chemical combination, yet the atom possessed two electrons, for it was expelled without them as an α particle; one of these electrons, at any rate, was detachable by electric agencies (positive ray analysis, *e.g.*). Professor Armstrong had years ago suggested that helium and the other inert gases were really compounds of such strong affinities that they could not be decomposed; he might not think so now. Those inert gases were the nearest approach to the electrically neutral atom. In the electro-positive alkali metals and hydrogen there was one more electron than was required to satisfy the positive charge on the ion; in the halogens (chlorine) the negative charge was insufficient; hence the mutual chemical affinity between elements of these two groups. It was difficult for a chemist to realise that affinity was due to a dissociating as well as to a combining tendency. There was probably only one affinity, that between oppositely charged spheres; but the atomic charges being enormous and the ranges in chemical action minute, this affinity was colossal. What the chemist recognised as affinity was due to the relatively slight differences between the magnitude of the universal tendency of the electron to combine with matter in the case of different electrons.

The confusion between the earlier and the present views concerning the relations between matter and electricity, Professor Soddy continued, was a further obstacle to the student. We knew negative electricity apart from matter as the electron; we knew positive electricity, apart from the electron, the hydrogen atom or the α particle (helium atom), and that was matter in the electrically uncombined condition. Whether we spoke of positive and negative electricity, or of matter and electricity, the dualism remained. On the other hand, the theory of electromagnetic inertia was true monism; it tried to explain two things, the inertia of the electron and the inertia of matter, by the same cause. There was no reason to assume that matter minus its electron was made of the same stuff as the electron itself.

Passing to complexity in the second sense, the lecturer remarked that the new radioactive method of analysis had at once yielded three new elements from uranium: radium; polonium (changing 4,500 times more rapidly than radium), of which a ton of uranium could only contain a few milligrams; actinium, equally rare because it was in a branch line of disintegration. Polonium resembled bismuth and tellurium, but had been separated from them; actinium resembled lanthanum. The three gaseous members, the emanations of radium, actinium and thorium, found their proper places in the periodic table as extreme members of the argon family, all being of about the same atomic weight.

But further members had been discovered in the

three disintegration series, the four longest-lived being radio-lead, or RaD, and ionium in the uranium series, and mesothorium I and radiothorium in the thorium series; they were not new elements, in so far as they did not possess new chemical characters, but there was no room for them in the periodic table, and they could not be separated by chemical means from the other constituents in the minerals. That latter property was not considered especially remarkable seven years ago, when the separation of the various rare earths, *e.g.*, was still very imperfect. The cases were not alike at all, however, for in the rare earths, &c., the atomic weight was the guide, and that failed in the radio-elements. In 1910, then, Professor Soddy had found mesothorium I—which had been kept secret for technical reasons—to have precisely the properties of radium, and Marckwald actually published the same fact before the lecturer, who, assisted by Mrs. Soddy, spent several months in further attempts to fractionate the radium-barium-mesothorium chloride obtained from the mineral thorianite. Thus in this case, and in several others, elements differing by from 2 to 4 units in atomic weight appeared



chemically inseparable and also chemically identical The conception of such elements, later termed isotopes, was first elaborated by the lecturer in the Chemical Society's Annual Report for 1910; the similar work of K. Fajans, to whom the conception is sometimes attributed, was published in 1913.

These views had since been corroborated by three lines of advance. Firstly, every member of the disintegration series which lived more than a minute had been chemically characterised, by A. Fleck, the lecturer and others; then sweeping generalisations had been effected in the interpretation of the periodic law; and, thirdly, a beginning had been made in the experimental study of the structure of the atom. Every case of non-separability had been confirmed by Paneth and von Hevesy, T. W. Richards and W. F. Hall, &c., by independent new methods. That might look a negative result; though thorium and ionium were inseparable, however, thorium was separable from all other elements. The spectra of isotopes had proved identical (A. S. Russell and R. Rossi over here, and the Radium Institute of Vienna), as the spectra were electronic in character, and Rutherford and Andrada had extended this identity to X-ray spectra. As regards the periodic table, an α-ray change (meaning a loss of two positive charges) sent the element two places away in the direction of diminishing mass (see diagram), and when in subsequent changes α rays were not expelled, the product frequently reverted to the chemical character of the parent, though the atomic weight was reduced by 4 units (helium = 4), making the passage across the table alternatory. The products of β ray (electrons) changes were mostly very short-lived and imperfectly characterised chemically; but the change meant a shift by one place in the opposite direction. Thus several elements were relegated to places already occupied in the table. But all those elements or products occupying the same places proved to be those which had been found to be chemically non-separable from one another and from the old occupant of the respective place; the name "isotope," indeed, indicated "the same place."

Having pointed out several of these characteristic radioactive changes,* Professor Soddy dwelt particularly on the ultimate disintegration product, lead. Resulting from thorium, atomic weight Th = 232 (or a little higher), by the loss of 6 α particles of mass $6 \times 4 = 24$, lead should have the at. w. Pb = 232 − 24 = 208; if it resulted from uranium, at. w. U = 238, by the expulsion of 8 α particles of mass $8 \times 4 = 32$, the at. w. of lead should be Pb = 238 − 32 = 206. But the at. w. of common lead was 207.2.† Thus it looked as if lead isolated from thorium minerals should be heavier, and lead isolated from uranium metals be lighter than common lead, and that the latter should really be a mixture of the two. The geological side of the problem had been discussed at the Royal Institution by Professor J. Joly the week before Professor Soddy's discourse. The publication of our report of Professor Joly's lecture, which dealt with Radioactive Haloes, has unfortunately been delayed by want of space, but it will appear in an early issue.

As regards uranium minerals, Professor Soddy went on to explain, geologists found that the lead accumulated in them during geological time agreed with their estimate of the age of the earth. But thorium minerals seemed to contain far too little lead to accord with geological ages. Professor Soddy was not deterred, however, from attacking the thorium-lead problem. Almost all Th minerals contained U, he said, and as U changed 2.6 times as fast as Th, it was a much faster lead producer. Thorianite from Ceylon, with up to 70 per cent. of ThO_2, contained also up to 30 per cent. of U_3O, so that any lead found in it might be of U origin. There occurred in Ceylon, however, also thorite, a hydrated silicate of thoria, with 57 per cent. of Th and only 1 of U; it was supposed to be free from lead, but Professor Soddy found 0.4 per cent. Pb in it. He had been fortunate in securing 30 kg. of thorite. Picking the thorite out carefully from thorianite and other minerals accompanying it, he isolated 70 grammes of lead, which proved denser than ordinary lead; assuming, with Rutherford, that the atomic volumes of isotopes should be the same, the density determination yielded an atomic weight of 207.74 for this Th lead. This lead and common lead were then distilled in *vacuo*, and atomic weight determinations were made after the method of Stas; these gave 207.694 and 207.20 for the two leads. On the request of Mr. Lawson—who worked in the Radium Institute of Vienna when the war broke out, and was allowed to continue his work there, though interned—Professor Soddy then sent the first portion of his thorite lead to Vienna, where O. Hönigschmid made an atomic weight determination (by the silver method), finding 207.77 ± 0.014 as the mean of eight determinations.

Simultaneously with these investigations the atomic weight of lead from different uranium ores had been determined by T. W. Richards, by M. Curie, and by Hönigschmid and Horovitz, the lowest result of the latter being 206.046, whilst lead from thorianite yielded 206.8 and from monazite 207.08. Richards and others also confirmed the conclusion that the atomic volume of isotopes was constant. There was hence no doubt that the lead from uranium was by about 1 unit lighter, and that from thorium by 1 unit heavier than common lead. The second quite independent case of isotopes differing in atomic weight concerned thorium and ionium, one of the uranium products which had disturbed the calculations on the growth of radium that Professor Soddy has been conducting for 14 years. So far the life period of ionium had seemed to be 100,000 years, against 60,000 years for uranium. Last year Miss Hitchins had definitely found radium in the 3 kg. of uranium preparation of the lecturer, and this growth was proceeding according to the square of the time, as expected. Now the ionium preparation obtained from the 30 tons of Joachimsthal pitchblende of Auer von Welsbach was almost free of thorium, and Hönigschmid and Horovitz found the atomic weight 231.51 for that ionium, whilst their renewed determination of the at. w. of thorium yielded Th = 232.12. If ionium were (radium + 1 α particle), as assumed, then its atomic weight should be 226 + 4 = 230. The figures found would indicate that the ionium preparation contained 30 per cent. of ionium and 70 per cent. of thorium, and would make it probable that the life period of ionium had to be raised to 150,000 years, in agreement with the determinations by Stefan Meyer (Vienna) of the numbers of α particles emitted per second by radium and by the ionium preparations respectively.

We cannot follow Professor Soddy into these intricate calculations; his estimate of the age of the earth from the consideration of thorite lead was 131,000,000 years, which is in good agreement with the geological estimate. If lead were itself unstable, it might turn into mercury by loss of an α particle, and into bismuth by loss of a β particle; of these two elements he could not detect any traces in the lead from his minerals. If, however, both an α and a β particle were expelled, thallium would result, and that was always present in small quantities. The conclusion which Professor Soddy rightly emphasised was that atomic weight determinations, already demanding supreme accuracy, will have to be conducted on new lines and be interpreted in a novel sense. If elements may be mixtures of isotopes, differing by a few units in atomic weight, atomic weight determinations lose their significance as ultimate quantitative tests of elementary character. In any case locality, geological age and the whole history of a mineral should be known, when it is to serve for such a determination. Further, Prout's thesis gains a new sense. The different elements may be multiples of one or two primordial elements. Professor Soddy suggested hydrogen and helium as possible ultimate constituents, and would ascribe the small deviations existing in the atomic weights of these constituents themselves to the manner in which the atom is constituted in accordance with the principle of mutual electromagnetic mass, as developed by Silberstein and others.

* Compare ENGINEERING, vol. xcix, page 604, 1915.

† The international tables of atomic weight still gave in 1914, Pb = 207.1; the revision raised this figure to 207.2, and this alteration affects the figures to be mentioned, which differ from those previously published by Professor Soddy in his first account of 1914. In 1900, 205.36 was the accepted value for Pb.

THE ELECTRICAL PROPERTIES OF GASES.

ON Saturday last Sir J. J. Thomson, O.M., P.R.S., delivered the third lecture of his course on the above subject at the Royal Institution.

In his opening remarks Professor Thomson said that in his last lecture he had explained the results

obtained by Mr. C. T. R. Wilson in his measurements of the electrical effects of thunderstorms. It thus appeared that in quite an ordinary storm some 30 coulombs of electricity passed with each flash from the cloud to the earth. He had since been asked if this observation could be reconciled with Faraday's conclusion that the total quantity of electricity in movement in a storm was comparable with that which could be obtained from a thimbleful of matter. It might therefore be interesting to put into figures what quantity of matter would be required to furnish 30 coulombs of electricity. The charge of electricity on the hydrogen atom was, in round numbers, 1.5×10^{-19} coulombs. Hence the number of atoms required to furnish 30 coulombs would be $\frac{30}{1.5} \times 10^{19} = 20^{19}$ atoms, or 10×10^{19} hydrogen molecules. In one cubic centimetre of hydrogen at standard temperature and pressure there were 2.75×10^{19} molecules, so that $\frac{10}{2.75} = 3.64$ cubic centimetres of hydrogen would be the amount of gas required to furnish the 30 coulombs of electricity.

He did not know whether Faraday's dictum had been quoted as a taunt to the thunderstorm or as a compliment to the electrical properties of matter. It had, however, to be observed that there was a great difference in the potential of the 30 coulombs bound up in 3.78 c.c. of hydrogen molecules with an equal amount of electricity of the opposite sign, and that of the same quantity in a thundercloud some miles above its corresponding positive charge. It was not possible to produce much in the way of electrical effects with even a large charge of negative electricity if it lay closely adjacent to an equal positive charge. The sole difficulty in getting such effects was to separate the two kinds of electricity, and this required the expenditure of work.

It was possible from Wilson's observations to find out upon what area of cloud the flash drew for the 30 coulombs it carried to earth. We knew how much electricity was required per square centimetre of surface to furnish an electric force strong enough to produce a spark. This amount was $\frac{8}{3} \times 10^{-6}$ coulombs, which therefore represented the charge on a square centimetre just before the flash. The area required to provide 30 coulombs was accordingly $\frac{30 \times 3}{8} \times 10^6$, or, roughly, 10^{10} sq. cm. = 1 sq. kilometre.

A peculiarity of the phenomenon was that the whole quantity came down in a single thread. The diameter of the flash was unknown, but was certainly not very large, and with this concentration of energy in a discharge of small cross-section it was easy to understand that enormous mechanical effects might be produced. These were, in fact, the speaker continued, considerable even with small-scale apparatus. This he demonstrated by placing a glass bulb, about 1½ in. diameter, filled with water between the two terminals of a large Wimshurst electrical machine, which were some 10 in. apart. On operating the machine the bulb was shattered to pieces by the spark.

He wished, Sir Joseph proceeded, to consider next a very interesting problem, a satisfactory solution of which had not even been approached till within the last few years. What, in short, was the mechanism involved in a thunderstorm? and how did Nature work to produce this huge electrical machine capable of giving sparks six or seven miles long? How was the energy accumulated? In reply, he might say that for long there had been little doubt as to an essential part being played by water. It was not actually necessary that rain must occur at the same place as the lightning, but there must be rain or heavy clouds in the neighbourhood. All theories of the thunderstorm looked to rain or clouds as in some way the origin of the storm. Lenard was the first to throw light on certain properties of water which were now believed to play a leading part in the generation of thunderstorms. Lenard found that whenever there was splashing of water electrification resulted, the two electricities being separated. This effect the lecturer showed by directing from a Goudie sprayer a very fine spray of water on the plate of an electroscope. The immediate divergence of the leaves showed that the plate was electrified by the spray. The charge on the plate was positive, but the air around the spray was negatively electrified. This experiment, the speaker continued, provided the essence of the modern view as to the production of thunderstorms.

It had long been known that there was something abnormal in the electrical conditions at the foot of a waterfall, which was in fact the source of some electrical disturbance, but the matter was not thrashed out until Lenard investigated it and showed that the water was positively electrified and the air negatively. He further showed that this electrification was extraordinarily sensitive to minute traces of impurity in the water. These might change not merely the amount of the electrification, but even its sign. Thus a trace of methyl violet too small for its presence to be detected by the eye would greatly affect the amount of electrification produced by a spray. This was, the speaker said, the more notable, since the coloration produced by methyl violet was so intense that it was frequently used for tracing out the flow of underground streams. This sensitiveness of the spray to impurities was discovered by Lenard, who found it impossible to repeat at Bonn experiments he had successfully made at Heidelberg, where the water supply was much purer.

Later experiments had carried the matter further and established a point which was fundamental in the theory of the thunderstorm. It had, in fact, been shown that whenever a drop of water split up, whilst still suspended in the air, the water of the drop was positively electrified and the surrounding air negatively electrified. Hence any process by which big drops were broken up into little ones, whether by clashing against each other or in other ways, constituted a potential source of electricity. It had been shown that if the surface of pure water was increased an electrical effect was produced. This was accounted for by the view that in its normal state a water surface covered itself with a coating of negative electricity which tended to stop the emission of further negative particles from the interior. If the surface were increased there would be nothing to stop negative particles coming out from the water to form a new coating. In this process some escaped and rendered the surrounding air negative, whilst the water became positively charged by the loss of these negative particles.

This electrification produced by the breaking up of a jet of water into a fine spray the speaker illustrated further by a very striking experiment. A fine jet of water was led through an orifice in the centre of a tin bath and rose vertically some 6 ft. or 8 ft. into the air before it broke up and fell back into the bath. In normal conditions the spray was so fine that the sound made was barely perceptible, but on bringing near the jet an ebonite rod electrified by friction the drops immediately became bigger, producing a very audible patter as they fell into the basin below. The jet, moreover, rose higher into the air before breaking up. In still another experiment the shadow of two jets of steam was thrown on to a screen, and it was shown that the shadows became much darker when a wire at the centre of the orifices from which the steam escaped was coupled up to an induction coil.

The foregoing experiments, the lecturer proceeded, showed that condensation was promoted and larger drops formed by the electrification. The application of these considerations to thunderstorms which he was about to make would, the speaker said, be found, for the most part, set forth at length by Dr. Simpson in vol. ccix of the Philosophical Transactions of the Royal Society.

In the first place, he continued, everyone must have noticed that raindrops never approached in size the dimensions of the largest hailstones. All sorts of statements were to be found as to sizes attained at times by the latter. He had himself found in one meteorological paper a statement that certain hailstones were as large as oranges or melons. Taking the most moderate estimate of the size of a melon, nothing even approaching such a figure was attained by a raindrop. The size of the latter had, in fact, a sharply defined maximum value, the diameter, very rarely, if ever, exceeding 5.5 mm.

The actual diameter was difficult to measure, but the evidence was strong that there was this definite limit of size. In short, if a big drop began to fall through air it was flattened into a more or less disc-like form by the resistance experienced. It thus exposed a large surface very liable to disturbances, which differed from point to point. These caused the break up of the drop, with the result that even a drop of 5.5 mm. diameter could not exist for more than a few seconds. Every time a drop broke up electrification was produced, each drop acting as a little electrical machine. In the case of hail there was no instability produced by an increase in size, and hence large hailstones were possible.

Before a thunderstorm there was somewhere or other a strong upward current of moisture-laden air. As this rose it got cooled, so that the moisture was deposited in drops. Unless these drops exceeded a certain size they would be borne up with the rising current of air. Suppose, however, that they were such a size as to be just supported, falling down just as fast as the current carried them up. If they got any bigger than this by further condensation they would fall, and in doing so break up into smaller drops. In this process the surrounding air would be negatively charged, and this charge would ultimately be transferred to the smaller droplets or spray formed on the break up of the big drops, whilst the larger residues would be positively charged. The small droplets, with their negative charges, were then carried up with the ascending current of air, which was unable to move the heavy larger drops. The two charges were thus separated, all the positively charged drops remaining at the bottom of the cloud, whilst the light negatively charged spray was carried up by the current against the attraction of the positive charges left behind. The result was that the bottom of a thundercloud bore a strong positive charge, whilst the negative electricity was carried up to the top of the cloud. Between the two a very strong field was established, and this field, it would be seen, was the outcome of the peculiar property possessed by water of setting free electricity whenever a drop broke up. The strength of the field increased as further charges were liberated, until finally a spark passed from the top to the bottom of the cloud.

If there was a horizontal current of air at the top of the cloud the charges would be separated horizontally as well as vertically, and in that case the strong field would be established between each part of the cloud and the earth immediately below it. The discharge would then take place from the cloud to the earth.

Summing up, it would be seen that the process of producing a thunderstorm commenced on the breaking up of large drops of rain into smaller drops and fine spray. The latter picked up negative charges from the surrounding air, and the work of separating this spray from the positively charged drops was effected by air currents. If these were wholly vertical the discharge took place within the cloud, but if at the top of the cloud a horizontal wind was experienced, the top and bottom of the cloud were separated horizontally, and a field established between each component and the earth below. The flash in that case passed from the cloud to the earth.

In the foregoing explanation he had, Sir Joseph proceeded, utilised but one of the various ways in which drops and spray acquired charges. In violent storms, however, the drops might knock against each other, and we might then get the effect of a little induction machine. Thus consider a drop in the electric field between the top and bottom of the thundercloud. By induction the top of the drop would be positively charged and the bottom negatively, and the drop would, moreover, elongate under the stress thus produced. If, then, the bottom of this drop were knocked off as the result of a collision, and was forthwith carried up by the air current, the arrangement would be the exact equivalent of an induction electrical machine.

If the views above set forth were correct we should have, Sir Joseph proceeded, a patch of cloud constituted at the bottom of large positively charged drops. If, then, the upward current failed, these

big drops would fall as the very heavy rain which was so frequent a concomitant of a thunderstorm, and these big drops should be positively charged. A great many experiments had been made to determine the kind of charge carried down by the raindrops which fell during a thunderstorm. The experiment was not an easy one, since if the drops were allowed to splash they would liberate negative electricity. There was, nevertheless, evidence that although the rain was sometimes positively charged and sometimes negatively, yet the heavy rain was always positively charged. Sometimes fine showers followed the heavy rain, and in this case the fine drops were negatively electrified.

As for the lightning, Wilson had found that sometimes it carried to earth a positive charge and at other times a negative one. This was quite in agreement with the view which attributed a discharge to earth to the drifting apart horizontally of the top and bottom of a thundercloud. The whole phenomenon was, it would be seen, due to the action of a kind of wind and water mill. Both water and wind were essential, the wind being necessary to carry the spray above the large drops or to knock the latter together, or to break them up if too big.

One remarkable effect sometimes seen had not been touched on in the foregoing theory. This was the thunderbolt or globular lightning. For his own part he had, Sir Joseph went on, never seen it himself, but there were a great many records of such experiences, constituting overwhelming evidence as to the occurrence of the phenomenon. In some cases a luminous ball was seen slowly falling to earth, disappearing when it reached the ground. In some statements this disappearance was said to be accompanied by a loud bang. So far this effect had not been satisfactorily explained. Another effect recorded was the running along the ground of a sort of luminous football. This might be merely a brush discharge over a line of metal piping under the surface of the ground, and was quite distinct from the globular lightning described in other records, which fell slowly from sky to earth.

What seemed to the speaker the most probable explanation was that this globular discharge differed in kind from the flash. The latter had, to begin with, to ionise the gas through which it passed, and it left its track in a conductive condition. An immediately succeeding discharge would therefore meet with quite different conditions, the track having been already prepared for it by the flash. The current in this discharge would, accordingly, not reach the same intensity as in the flash, but be more analogous to a continuous discharge.

To illustrate the resultant difference the lecturer took a discharge tube, and passed through it an intermittent current of such a periodicity that the ionisation produced by one discharge had disappeared before the next followed. Each discharge had therefore to prepare its own track. In these circumstances the appearance of the tube was uniform from top to bottom, no one point being more luminous than another. A current of much higher frequency was next passed through the same tube, and in this case there were marked differences in the appearance of the glow, striæ, or alternate patches of brightness and darkness, being very visible in the upper part of the tube. The difference was due, the lecturer stated, to the fact that in this second experiment the effects of one discharge had not died away before the next came.

Globular lightning, in his view, was accordingly a slow continuous discharge, with the peculiarity that the luminosity was concentrated into a ball. It was, moreover, possible to produce a discharge tube in which the luminosity was concentrated into a ball, and this ball could be caused to travel up and down the tube. This experiment the lecturer showed with a vertical discharge tube fitted with a Wehnelt cathode. By suitably adjusting the resistances in the same circuit with the tube, the discharge took the form stated, and was caused to shift up or down the tube at will.

This was, he said, the closest analogy he could find in the laboratory. He had, however, never himself seen the phenomenon of globular lightning, but the records left no doubt as to its existence, though the evidence was less satisfactory as to its ultimate disappearance with a loud explosion, or that it got into rooms and blew the windows out when it burst. The sulphurous smell, also recorded, appeared quite likely, being attributable to the formation of oxide of nitrogen. Those who had the fortune to see it should note the rate of fall and whether the globular discharge followed immediately after a flash. It need not necessarily follow the same path as the flash, since the ionised channel produced by the latter might be drifted some way off by the wind.

NOTES.

Pure Iron.

In a recent issue of the *Journal of Industrial and Engineering Chemistry* Mr. John E. Bucher states that iron may be freed from carbon by heating it in an atmosphere of nitrogen and sodium vapour. In this case he finds that the carbon is removed from the iron as a cyanide in virtue of the catalytic action of the iron itself. A notable point is that the carbon is removed by a reducing process instead of by an oxidising one, so that the iron is not attacked after the carbon is removed. The author states that sulphur, oxygen and phosphorus can be got rid of in the same way. He suggests, accordingly, that silicon and manganese might be removed from iron by an oxidation process carried, if need be, so far as to overburn the metal. By subsequently treating the iron with sodium vapour and nitrogen the oxygen, carbon, sulphur and phosphorus could be eliminated. With very cheap sodium it might be possible, he says, to apply the principle to purifying iron from ores very rich in phosphorus. In testing the method a number of hacksaw blades were heated to redness in an atmosphere of sodium vapour and nitrogen. They came out, after some hours' treatment, very soft and silvery white in appearance, and could not be tempered, thus showing that the carbon had entirely disappeared. In a similar test with a piece of steel wire the removal of the carbon was so complete that when made the anode in dilute hydrochloric acid it remained bright, showing no trace of carbon as the metal dissolved. The process described is the inverse of case-hardening, and the author of the paper states that by modifying the conditions the reaction may take place in the opposite direction. Thus on heating sodium cyanide with a powder of pure iron, in an iron tube, metallic sodium was produced. It may be noted that the whole investigation originated in the attempt to find a commercial process for fixing atmospheric nitrogen by means of the alkali metals to form cyanides. In this, the main research, it is claimed that full success was attained.

The Burning-in of Manganese Bronze.

The aqueduct built a few years ago for supplying New York with water from the Catskill Mountains, north of the city, was provided with valves of manganese-bronze castings weighing up to 22,000 lb. The valves were burnt in in the usual way, but owing to the heavy masses preheating of the material or subsequent annealing was not attempted. Within a few months some of these valves turned leaky under pressures of a few pounds, though they had originally been tested at 200 lb. or 300 lb. per square inch. The faulty valves came from at least three different works. The leakage was due to fine cracks in or near the welded parts; sometimes the cracks could only be detected under hydraulic pressure. Mr. A. D. Flinn, of the New York Board of Water Supply, brought the case before the American Institute of Metals in 1915 and also before the Bureau of Standards. On behalf of the latter body Messrs. Paul D. Merica and C. P. Karr determined the stresses which the local heating and unequal contraction of different parts of the casting left in the material (Technologic Paper No. 84). The form of casting chosen for the inquiry was a double-bar frame, consisting of a bar A, 1 in. square, and a bar B, 3 in. square, separated by more than an inch of air space, but joined by heavy end-pieces. Specimens from ½ in. to 2 in. in length were cut out of the central portion of A by means of the saw, and the gaps then filled up again by burning-in with the same material. The pouring gates for the burning-in having been sawed off, gauge points were placed on A, about 8 in. apart, and readings were taken with a strain gauge before sawing through A, outside one of the two gauge points. Knowing the elastic modulus of the material and the contraction over the 8-in. length, the value of the stress in A could be calculated. For effecting the welding the casting was placed on its side in green sand, which was hollowed out to expose the ends, these being further preheated by means of a torch; the bar B was kept cool, and to make sure of this a longitudinal 1-in. hole was run through it for water-cooling in one of the seven tests mentioned. The experimenters calculated a tensile stress of 36,000 lb. per square inch for every inch of metal burnt in; the actually resulting stresses ranged from 8,000 lb. to 10,000 lb. per square inch, irrespective of the length burnt in (¼ in. to 2 in.). That indicated that at some temperature the resulting stress became greater than the elastic limit of the material, and the material yielded thenceforth, the stress following (with some time lag probably) the elastic limit of the material, such that the stress as measured a day or two after burning-in represented the true elastic limit of the material. In a tensile test a specimen from A broke just outside the welded area, but not at the juncture of the original and the welded-in portion; the welded-in portion was harder and less elongated than the original material. The microstructure of the burnt-in metal fully accounts for the increased hardness; there was an abrupt change from the original fine grain to the coarse irregular grain of the burnt-in bronze. Otherwise there was no change in the material, whilst in autogenous welding with the acetylene blow-pipe zinc is burnt out. Subsequent annealing of the bar A by means of a wire coil made no difference in the stresses; as the part B had been kept cold—the water-cooling hardly made any difference, either—the part A should really have been cooled by 50 deg. or 100 deg. C. to relieve the stress in A. In the spherical shell or dome-shaped valves the burning-in would tend to flatten the shell and so to relieve the stresses; yet even in those cases local stresses equal to the true elastic limit would probably be produced. To prevent failure the authors can only recommend preheating or annealing of the casting to 400 deg. or 500 deg. C. for one or two hours. The bronze in question, though styled a manganese bronze, contained no manganese, consisting of 58.5 per cent. of copper, 39.1 of zinc, 1 of tin, 1.4 of iron, and a trace of lead.

The Mercantile Year-Book.—We have received a copy of the Mercantile Year-Book and Directory of Exporters for the current year, the thirty-first annual edition. It is edited by Mr. Walter Lindley Jones, F.R.G.S., and is issued at the price of 15s. by Messrs. Lindley Jones and Brother, 16, St. Helens'-place, Bishopsgate, E.C. It covers London, Manchester, Liverpool and the other large British trade centres, Paris, Bordeaux, Milan, Genoa and other continental centres. The exporters of London are arranged in street order, as in the former editions, according to a number of itineraries; in Part II are classified the importers in British Colonies and foreign countries, the class of goods dealt with and the names of the buying agents being given. Other useful chapters are directories as per the names of firms and classes of goods, both for London and other principal towns.

Road Construction and Improvements. — On Friday, June 1, at the Surveyor's Institute, 12, Great George-street, the discussion on Mr. Rees Jeffreys' paper "Road Construction and Improvements by means of the Town Planning Act" will be resumed. The chair will be taken at 6 p.m. The Town Planning Institute have published the contributions of those who have already taken part in the discussion. The contributors include Sir Herbert Jekyll, K.C.M.G.; Colonel Hellard, C.B.; Mr. H. P. Bulnois; Mr. J. Walker Smith (Local Government Board for Scotland); the borough engineers of Great Yarmouth (Mr. J. W. Cockrill), Blackpool (Mr. J. S. Brodie), Edinburgh (Mr. A. H. Campbell); the county surveyors of Surrey (Mr. A. Dryland), Herts (Mr. Killick), Durham (Mr. A. E. Brookes), North Riding (Mr. Bryning); Mr. Lewis Beard (town clerk, Blackburn); Mr. F. H. Owers (county accountant, Essex); Messrs. Aldridge, Shaweross, Culpin, George Cadbury, junr., Lawrence Chubb; and Professors Cannan and Abercrombie. Mr. Jeffreys completes his survey of the progress of town planning by including an appendix relating to Scotland. In his reply on the discussion he warns those who are interested in housing and road transport facilities from looking to the State to provide new roads. This, he suggests, is a function of local authorities, and by combinations of area they should be constituted and equipped for the purpose. Copies of the discussion, as well as the original paper, can be obtained by those interested from Messrs. Ede and Townsend, 30–34, Tabernacle-street, E.C. 2.

THE LATE SIR ALEXANDER RICHARDSON BINNIE.

WE regret to have to announce the death, which occurred last Friday, the 18th inst., at Beer, Devon, of Sir Alexander Richardson Binnie. Sir Alexander was born in London on March 26, 1839. We may here remark that in the opening of his presidential address to the Institution of Civil Engineers, delivered on November 7, 1905, he said he found it almost impossible to trace the causes which had converted the humble pupil who first attended the Institution's meetings in May, 1858, into their president; he could, however, he added, in a dim way indicate two main forces which had been in operation, namely, inheritance and the circumstances which had surrounded his life. From his parents he had inherited those greatest of all blessings, a sound constitution and a domestic training, for which at all times he felt the greatest thankfulness.

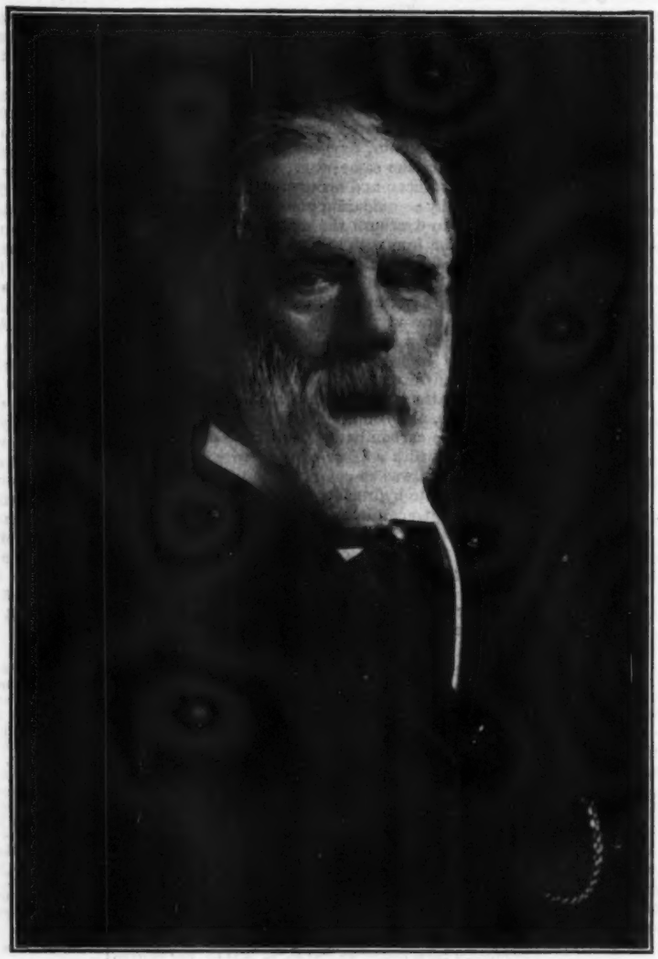
After receiving his early education in private schools the young engineer, the subject of this memoir, who was in course of time to become President of the Institution of Civil Engineers, served a regular term of pupilage under Mr. Terence Wolfe Flanagan and Mr. John Frederic La Trobe Bateman. He referred to these two gentlemen in his address above alluded to, and added that, beyond the influences he mentioned, and quite outside his more immediate professional work, he had been largely guided by social surroundings and by the teaching of such scientists as Huxley, Darwin, Tyndall and others who, during his lifetime, had so largely altered our conception of Nature.

From 1862 to 1866 the deceased was engaged in various works for the Welsh railways; for part of this time he acted as assistant engineer on the Mid-Wales lines under Mr. John Watson and Mr. Richard Smallman, and was also employed on the Neath and Brecon Railway, under Mr. J. G. McKenzie, and on the extension of the Pembroke and Tenby Railway, under Mr. J. Mathias. Then for a few years, down to 1868, he practised in London as a civil engineer on his own account. In January, 1868, having been appointed to the Public Works Department, he proceeded to India as executive engineer, and for several years was engaged in the full discharge of his duty in the Central Provinces, partly on coal exploration, railway service—in general charge of the Nagpur Division—and in the preparation of projects for the supply of water to several small stations. He also prepared designs and carried out the works necessary for supplying the city of Nagpur with water. In April, 1871, he was promoted in the Indian service and acted for several years as assistant secretary to the Chief Commissioner, Central Provinces, Public Works Department, and as assistant to the Chief Engineer.

Sir Alexander returned to England from India in 1875, and held for 15 years the appointment of water engineer to Bradford, where he carried out several water supply schemes. He then became, in 1890, Chief Engineer to the London County Council, a position which he held down to 1901, during which period—in the years 1894 to 1895—he was engaged in working out a scheme for the supply of London with water from North Wales. The areas from which the water was to be derived are composed of the impermeable beds of primary rocks of the Old Red Sandstone and Silurian systems, which are noted for the purity of the water flowing from their slopes. From a total area of 312,400 acres, or 488 square miles, he calculated that 415,000,000 gallons per day could be obtained, after allowing for all losses. The report which he drew up at the time compared this supply with the Thames supply. The rainfall in the Thames Valley, being 27 in., gave 300,000,000 gallons per day, without compensation, from the 3,542 square miles in the Thames Valley above Molesey. In the Welsh scheme pumping was unnecessary; the water was to be obtained chiefly from the valleys containing the springs of the Wye and Usk, and was to be brought to London through two main aqueducts, one for North London and the other for South London. Their length was to be from 150 to 170 miles, and they were to have a capacity of about 200,000,000 gallons per day. The Welsh scheme was admirably worked out in every detail by Sir Alexander; its cost to London (some 40,000,000*l.*) was, however, deemed prohibitive, and, much to its author's regret, it was ultimately abandoned for the alternative one, which consisted in increasing the water supply to London from the Thames and the River Lea, the Royal Commission having declared that the water already supplied to the London consumer was of a very high standard of excellence and purity and that no danger existed of the spread of disease by the use of Thames and Lea water provided there were adequate storage and provided also the water be efficiently filtered before delivery to the consumer. Although the accuracy of these conclusions has repeatedly been demonstrated since, Sir Alexander never completely renounced his Welsh water supply scheme, a pet plan of his, to which he frequently referred in after years.

During his period of activity as Chief Engineer to the London County Council Sir Alexander completed the sewage disposal works at Barking and Crossness; he also built the Barking road bridge over the River Lea and the new Highgate Archway, and laid out the Aldwych and Kingsway sites in the Strand. He was responsible also for the construction of the Blackwall tunnel under the Thames, which, in a paper read before the Royal Institution in March, 1896, he stated was one of the most difficult engineering works that had been carried out in London during the past 50 years.

Sir Alexander was knighted in 1897; he was elected an associate member of the Institution of Civil Engineers in February, 1865, and was made a full member in May, 1873. He was president of that Institution from November, 1905, to November, 1906, and was awarded on different occasions the Telford medal, the George Stephenson medal, and



[*From a photograph by Elliott and Fry.*

THE LATE SIR ALEXANDER RICHARDSON BINNIE.

a Telford premium. He was also a member of the Institution of Mechanical Engineers from 1887, and a member of various other societies. He contributed to all these a number of papers which give evidence both of his engineering capabilities and of his thorough acquaintance with a large variety of subjects; these papers form most interesting reading, as do also his frequent contributions to the discussions at the meetings which he attended. He had been an invalid for several years, and this, combined with the amputation of one of his legs which he unfortunately had to undergo some time past, set a seal to all his further activity. He was of a most benevolent disposition and will long be kindly remembered by all the members of the engineering profession with whom he came in contact, and particularly so by the younger members, whom he was always eager to guide.

INDUSTRIAL NOTES.

THE Board of Trade announce that the Government have decided that it is necessary to release more men from the coal mines for service with the Colours. After consultation with the Miners' Federation it is proposed in the first place to recruit from amongst men employed at coal mines who are of military age and who entered the coal-mining industry since August 4, 1914, and were of military age at that date, except only men at present engaged as (*a*) winding enginemen, (*b*) pump men, (*c*) electricians, (*d*) fitters and mechanics (including blacksmiths, joiners and wagon and tub makers and repairers).

Accordingly the certificates of exemption of the men thus becoming available for service with the Colours have been withdrawn by an Order dated May 12, 1917, and made by the Home Secretary. It is, however, only proposed at present to recruit men who may be medically classified A, while B and C men will be allowed to remain in the industry.

Every man thus becoming available for service will have the right of appeal to the Colliery Recruiting Court upon grounds of misdescription of his occupation, age, or date of entry into the industry, and to the ordinary tribunal on private grounds within the usual time limits.

With further reference to the London bus strike (see page 470 *ante*) the Government last week took action in the hope of assisting towards a settlement of this dispute. At a conference held on the 16th inst., between representatives of the London General Omnibus Company and the London and Provincial Union of Licensed Vehicle Workers, with representatives of the Transport Workers' Federation present, the Right Hon. Arthur Henderson, M.P., after hearing the views of both parties, submitted the following proposals with a view to a settlement:—

1. That the London and Provincial Union of Licensed Vehicle Workers withdraw the letters dated May 3 and 4, thus bringing the relations of the company and the union into the position which existed prior to the decision taken at the annual delegate meeting of the union.

2. That the agreement entered into on September 22, 1913, be subject to review at a conference, to be presided over by Sir George Askwith, between representatives of the company and the union, at an early date, to be mutually agreed upon.

3. That there be an immediate resumption of work on the part of members of the union.

4. That the reference of the application for a war bonus be proceeded with by the Committee on Production and that any award made by that committee take effect as from the date on which work is resumed.

5. That, at the request of Mr. Henderson, the London General Omnibus Company undertake to re-engage the 10 employees concerned in the Palmer's Green incident.

The representatives of the company and the union undertook to present the above proposals to those whom they represented and to recommend their acceptance. Subsequently it was officially reported to Mr. Henderson that both parties had agreed to accept the above proposals and work was resumed on the 17th inst.

In the great world war in which America is to take a belated but decisive part, says *Power*, New York, it is not the uniformed forces and the military equipment alone which are to win. There must be no failure to realise the magnitude and the vital import of the task; there must be no delay in mobilising the forces of agriculture, mining, industry and transportation. An artificially created scarcity, local or general, for the purpose of enhancing prices, reprehensible enough at any time, becomes an intolerable atrocity which should be summarily dealt with. The war will bring enough real hardships and sacrifices without being made the excuse for further extortion. The workers winning the war must be protected against any unavoidable impairment of the purchasing power of their day's wage. On the other hand, labour must not take advantage of its essentiality. Not only must there be no interruption to production and distribution by strikes, but the efficiency of the industrial system must not be impaired by the refusal of labour to do its part in speeding-up the system. A recognised American authority, adds our contemporary, estimates that the present industrial outfit of tools and machinery in the United States could, with intelligent adaptation and management and the willing co-operation of the operators, be made to produce four or five times the present output. Whoever takes advantage of existing conditions to counsel labour to refrain from showing what it can do to win the war for fear of setting new standards of capacity, whoever counsels strikes, which in addition to impeding output furnish opportunities for the exercise of violence against the country's institutions and resources, should be treated as are those who give aid and comfort to the foe.

Dealing also with the war, *The Iron Trade Review*, Cleveland, Ohio, states that the practical mobilisation of the steel industry on a war footing has been accomplished through the putting in working trim of measures of complete co-operation between the manufacturers and Government. Machinery for the purchase and distribution of essential supplies has been fully provided and is running smoothly. Enlarged facilities are being established or recruited rapidly under Federal direction for working up raw material into heavy ordnance, shells and other implements on a new scale of magnitude for the United States. Historic conferences at Washington among representatives of the great allied Powers will determine the question as to how far manufacturers will be called upon to furnish preferred deliveries of finished munitions, of munition steel and other products to England and France especially. This decision will be of much importance to the steel industry and to the market because of the tonnage involved. Large additions to business now booked for the *entente* nations are up for settlement. England is a prospective buyer of 100 steel vessels to be constructed immediately in American yards.

The Minister of Munitions wishes to announce that, in view of the situation created by the entry of the United States of America into the war, the War Cabinet have decided that it is no longer necessary to proceed with the erection of the large explosives factory now under construction near Bristol. Instructions have accordingly been issued that steps are to be taken to bring the work to an end as soon as possible, due regard being had to the question of creating as little hardship and dislocation among the workmen and suppliers as circumstances will allow.

Since the war broke out the cotton spinners and cardroom workers have had their wages increased by 20 per cent.; the weavers had obtained an advance of 10 per cent., and a movement was lately set on foot by the Northern Counties Textile Federation, Weavers' Amalgamation and other unions, for obtaining for the weavers, power-loom overlookers, twisters and drawers, an advance of 20 per cent. over and above the 10 per cent. in question. The weavers intended to hand in their notices to cease work to-morrow should their demand not be conceded. The movement involved over 200,000 operatives. A meeting of employers and men under the chairmanship of Sir George Askwith was held last Tuesday at Preston, when the operatives concerned were offered an advance of 10 per cent., thus placing on an equal footing the whole of the operatives in the cotton trade. The offer is to be considered at a meeting of operatives to be held to-morrow at Blackburn; it is hoped that an amicable settlement will now be arrived at.

The Press Bureau states that a conference was held at the Ministry of Munitions last Saturday between the Minister of Munitions and the Executive of the Amalgamated Society of Engineers, who were accompanied by a deputation from the unofficial strike conference. The interview began with a statement by the chairman of the Amalgamated Society of Engineers, who intimated that he was there to introduce the deputation with the authority of the executive, and that the deputation wished to lay the facts of the situation as they saw them before the Minister. The delegates thereupon stated the grievances of the men in respect of the abolition of the trade card scheme, the Munitions of War Amendment Bill, and other matters. They then withdrew and left the Executive Council and the Minister of Munitions to consult upon the situation. The Executive Council placed certain considerations before the Minister, who stated that before replying he would be glad to know what action was proposed to be taken by the society to arrive at a settlement of the present difficulties. The following resolution of the unofficial strike conference was thereupon read:—

"That we hereby request the Executive Council to attend with us at the Ministry of Munitions in order to state our case and then immediately return to our districts, telling them we have carried out our mandate and advise them to return to work, leaving the matter with the Executive Council on receiving assurances of no further arrests, of no victimisation, and in regard to releases."

Subsequently there was a conference at 10, Downing-street, at which the Prime Minister presided and a settlement was arrived at.

The following statement was then issued by the Executive Council of the Amalgamated Society of Engineers:—

"In order to give full effect to the agreement entered into with the Ministry of Munitions and confirmed by the Prime Minister on behalf of the Government, and in accordance with the resolution of the deputation elected by the strike conference, the Executive Council instruct all members who are now on strike to resume work immediately.

"On behalf of the Executive Council: (signed) J. T. Brownlie (chairman), Robert Young (general secretary)."

We deal generally with the labour situation in an article in our present issue, and regret to add that in several of our industrial centres the position had not improved to any marked degree at the time of our going to press.

CONCRETE SHIPWAYS AT FORE RIVER.—According to *Engineering News-Record*, New York, concrete ways 990 ft. long will be built by the Fore River Shipbuilding Corporation to handle one of the new battle-cruisers recently authorised by Congress. For the foundation, supporting crib, blocks and launching ways, over 12,000 cub. yards of concrete and 3,000 wooden piles will be required, whilst 3,000 tons of structural steel will be placed in the 870-ft. craneways. There will be one 50-ton and three 7½-ton electric cranes, all of 120 ft. span, the large crane running 121 ft. above mean water-level. While the Aberthaw Construction Company is pushing this preliminary work, which will cost 500,000 dols., shop work on the cruiser is going forward. The ways should be ready for the keel by September 1.

NEW GOVERNMENT LABORATORY IN JAPAN.—The Emperor has headed the list of subscribers to the new Government laboratory in Japan, and has given 1,000,000 yen. The rich have consequently subscribed in regal fashion, and the money collected has reached over 6,000,000 yen. Probably it will not be long before it reaches 1,000,000*l*. This is undoubtedly a very fine start, and shows that the Japanese do not intend in future to be behind-hand in scientific research. Branches of all scientific work will be taken up, and the best men will be engaged. The plan is that anyone can get work done by the staff at a very reasonable fee. The founders of the Laboratory of Scientific Investigation met in conference at the Tokyo Chamber of Commerce in April and elected Baron Mitsui, Baron Iwasaki, Mr. Hara, Mr. Yasuda, Baron Shibusawa and Baron Furukawa advisers. The offices of the Institute were installed in the Chamber of Commerce Building.

POWER FOR AGRICULTURAL PURPOSES IN BRITISH INDIA.—In the annual report for 1915–16 of the Department of Agriculture of the Bombay Presidency, a copy of which has recently been received at the Department of Commercial Intelligence, Board of Trade, the Director of Agriculture writes that the erection of power plants for agricultural purposes in the Presidency continues, 10 having been erected during the year. Repairs were also carried out by the Department and advice given to many owners or prospective owners of agricultural machinery. Instruction in engine driving is being given at the workshop of the College Farm, and everything possible is being done to overcome the initial difficulties which must occur when inexperienced people take to the use of machinery. The present high prices of machinery and of fuel oil tend to restrict the use of oil engines, but with a return to normal prices there must be a good future for developments of this kind in many parts of the Presidency. Each of the steam ploughs owned by the Department worked at a small profit after paying all charges, including depreciation and interest. In Gujarat, during the year, 1,203 acres of rough, virgin land were broken up to a depth of 1 ft., and the large clods harrowed down at a cost of 16 rupees per acre. In the Dharwar district 554 acres of grass-bound land were broken up to a depth of 16 in., at a cost of 25 rupees per acre, and by way of extending the short working season a further area of 146 acres was subjected to shallow ploughing. There is a good demand for these operations at the charges made, and the organisation is improving. In Gujarat steam ploughing appears to be a sound business proposition, while in the East Deccan, where the rainy season is a very short one, it is believed that this would also be the case. For deep ploughing in these heavy soils it is probable that more powerful engines than those used would be more economical, and, the Director states, this is a matter which should be borne in mind by the Department when the next investment in steam ploughs is made. In all branches of agricultural engineering a strenuous year's work was accomplished and steady progress maintained.

CAPITAL AND LABOUR IN CO-OPERATION.

A MEETING of the general committee of the National Alliance of Employers and Employed was held on Tuesday last at the headquarters of the Alliance, 64, Victoria-street, London, S.W., when, after a full discussion, the new constitution was adopted. The Hon. Frederick Huth Jackson (chairman) presided, and among those in attendance were Mr. W. A. Appleton (General Federation of Trade Unions), Mr. J. M. Bell (National Union of Labour), Mr. H. H. D. Anderson (Associated Portland Cement Manufacturers), Sir K. Crossley, Bart. (Crossley Brothers, Limited), Mr. J. Crinion (Card and Blowing Room Operatives), Sir V. Caillard (Vickers, Limited), Mr. B. Cooper (Cigar Makers), Mr. C. Coleing (Drapers' Chamber of Commerce), Mr. F. D. Docker, C.B. (president of the Federation of British Industries), Sir A. Firth, Bart. (Firth and Sons, Limited), Mr. F. Gilbertson (Pontardawe Steel, Tinplate and Galvanising Works), Mr. I. Gwynne (Tin and Steel Mill Men's Union), Sir R. Hadfield (Hadfield, Limited), Mr. J. Henson (National Seamen's and Firemen's Union), Mr. J. S. Hill (Engineering and Allied Trades Societies Federation), Mr. E. Manville (Daimler Company), Mr. Mallalieu (Felt Hatters' Union), Mr. H. H. Marshall (Marshall and Sons), Mr. W. Mullin (Card and Blowing Room Operatives), Mr. F. Moore (Moore, Eady and Murcott Goods), Mr. R. T. Nugent (Federation of British Industries), Mr. Arthur Pugh (British Steel Smelters' and Kindred Trades' Association), Sir H. Rogers (Birmingham Small Arms Company), Mr. J. Taylor (Midland Trades Council), Mr. A. Todd, (Ironfounders' Friendly Society), Mr. V. H. Smith (Gloucester Railway Carriage and Wagon Company), Mr. J. H. Wilson (National Seamen's and Firemen's Union), and Mr. W. J. Davis (Brass Workers and Metal Mechanics). The chairman referred to the gravity of the prevailing unrest not only among workmen, but equally among employers and business men. It was necessary for the Alliance, he said, to strengthen and extend its organisation as rapidly as possible, so that employers and employed, acting together, should assist and perhaps guide the Government in the difficult and involved situation which had arisen. The constitution of the Alliance should be broad and comprehensive enough to obtain the practical co-operation of everyone associated with the industrial life of the nation. There had been a better relationship growing up between employers and employed, but he thought it had to be admitted that in a good many cases workmen had not in the past received a due proportion of the results of their industry. Employers must recognise that workmen in the future must be better paid than they had in the past, better housed, and better educated. The workman, on the other hand, must recognise that a full wage carried with it the obligation of a full day's work, and that where a full day's wage is paid interference with the productivity of industry must not be allowed. The chairman moved the adoption of the constitution, the main objects of which are:—To secure the active co-operation of employers and employed in the discussion and treatment of questions affecting labour and employment, with the special object of securing that these should be dealt with before they have reached the stage of acute controversy. To promote generally the welfare of the industrial workers of the country and the efficiency of its industries. To arrange in conjunction with the proper departments of the Government, as one of the most urgent problems, for the reinstatement in civil employment at the end of the war of men serving with the forces and munition workers. A resolution was also passed urging the Government to abstain in future from action affecting the conditions of manufacture and employment until the joint advice of employers and employed has been obtained, and from interference in industrial disputes until every form of direct negotiation had been exhausted.

AMERICAN EXPORTS.—There are persons who would have the American people believe, says *Machinery*, New York, that the increase in the United States exports from 2,484,000,000 dols. in 1913, to 5,481,000,000 dols. last year, was due almost wholly to shipments of munitions. But the following, taken from official reports, shows the share of munitions in this trade:—

	1916. Dols.	1913. Dols.
Total	5,481,423,589	2,484,018,292
Agricultural products	1,488,195,846	1,071,401,508
Foodstuffs ...	1,069,339,383	494,414,640
Supplies	924,599,000	218,637,000
Cotton	543,529,808	575,488,000
Breadstuffs ...	471,952,100	203,391,856
Meat and dairy products ...	279,198,960	157,486,409
Mineral oils ...	201,732,563	149,316,400

The heading "Supplies" covers metal, machinery, chemicals, shoes, horses, brass and copper. Neutrals received a part of these exports, and a part was used by belligerents in normal ways. The values of the munitions exported and other products associated with the war are as follow:—

	1916. Dols.	1913. Dols.
Munitions ...	813,791,000	20,794,000
Accessories ...	131,128,000	28,907,000
Total	944,919,000	49,701,000

Under the heading "Munitions" are explosives, fire-arms, aeroplanes and barbed wire. The "Accessories" include automobiles, not all of which were war material, motor cycles and surgical instruments. The export of munitions as to which there is no room for doubt were only about one-seventh, or 14½ per cent. of the total.

NOTES ON THE CONSTRUCTION OF TURBINE PUMPS.*

By ALAN E. L. CHORLTON, of Lincoln, Member.

THE turbine has become so highly successful as a pumping engine for duties of all descriptions, that no apology is needed from the author for again returning to the subject and offering a few practical notes on the design and construction of its detailed parts.

In passing, it is interesting to refer on the theoretical side to the early French works of M. Poncelet (1838)† and M. Combes (1843)‡ on reaction wheels generally; also to the two papers on the mathematical principles involved in the centrifugal pump by Mr. Andrew J. Robertson in the Proceedings of this Institution, 1852 and 1853, culminating in the classic work of Dr. Unwin in the Proceedings of the Institution of Civil Engineers, 1877–78. Early practical applications of accepted principles have been given by such work as that of Mr. Appold, 1848–51, with his well-known pump, Professor James Thomson,§ with his vortex or whirl-chamber pumps put down in 1852 to 1858, and by Mr. R. C. Parsons in experimental work described in a paper read before the Institution of Civil Engineers in 1877. Latterly practical development has been furthered by experimental work on the efficiency of centrifugal pumps by Dr. Stanton, and published in the Proceedings of this Institution in 1903, by the experiments on the fluid friction of rotating discs carried out by Dr. Unwin and described in the Proceedings of the Institution of Civil Engineers, vol. lxxx, and more recently by the very valuable work of Professor Gibson,‖ extending over wide ground both directly and indirectly affecting the centrifugal pump. These are milestones in the history of the evolution of the centrifugal pump, yet the wide extent of its successful practical application in turbine form is due to the overcoming of practical difficulties both mechanical and hydraulic. This work has only been accomplished after prolonged experience, and success has only been reached after tedious and careful study and improvement of small details.

The object of the present paper is to describe and trace the development of some of the methods of successfully overcoming the difficulties referred to, and to draw attention to points in design which are the result of the author's experience extending back to the infancy of the application of the turbine-pump principle.

It will be convenient to consider the subject under the headings of the various component parts of a pump. These are:—

I. THE STATOR, which consists of (I *a*) the casing or housing and (I *b*) the guide vanes or appliance for converting velocity energy into pressure energy.

II. THE IMPELLER (considered separately).

III. THE BALANCING APPLIANCE—hydraulic or mechanical.

IV. THE ROTOR, considered as a whole, and including the spindle, with its projecting sleeves, impellers, and in most cases the balancing appliance.

V. THE BED, and other details, bearings, stuffing-boxes.

Of these components III, IV and V, broadly speaking, are the factors governing reliability and resistance to wear, and I *b* and II are those determining the efficiency.

The author proposes to deal at greater length with III and IV, for the reason that they have probably been less discussed than the others, also their practical importance is of the greatest moment, and he cannot deal with the whole subject adequately within the confines of a paper written during the present time.

The chief points only of items I, II and V will be briefly reviewed:—

I. CASING.—The individual impellers of a turbine pump revolve in chambers or cells containing the outward flow guide passages, and the return conduits for the water; these chambers may be part of a whole in which the outer body is cast in one piece, or an aggregation of a number of distinct cells without any outside envelope. There are therefore two main types:—

(1) The Osborne Reynolds or divided type, sometimes called the "ring type."

(2) The Sulzer, integral or one-piece type, sometimes called the "cylindrical" type. Recent American practice provides a variation of this type with the housing in halves, divided on the horizontal centre line.

The two main types are diagrammatically illustrated by Fig. 1 (*a* and *b*) and Fig. 2 (*a* and *b*) with variations in Figs. 3 and 4 (page 509).

The Osborne Reynolds pump and its evolution was dealt with by the author, in collaboration with Dr. E. Hopkinson, in some detail in a paper read before the Institution in January, 1912. This type was followed at a later date by the integral one of Sulzer, which had, for a period, a considerable vogue. An examination of the present-day practice of various makers will prove, however, that the ring type has ultimately proved the preferred one. The Reynolds' pump* has always used a separate cell for each impeller, and it is therefore correct to say that the ring type of pump owes its inception to this country.

The Continental form of the series turbine pump is due to Sulzer (first pump 1896), and in this type a monoblock housing was used for all the chambers or cells, the guide vanes being inserted from the end.

Before dealing with either type, or variations arising out of them, it is advantageous to consider the essential functions of the chamber or housing of a turbine pump. Primarily, each cell consists of (1) the outward flow guide passages, in which the kinetic energy of discharge from the turbine impeller is converted into static head, and (2) the return water passages back to the centre for conduction to the next impeller; a complete housing is a collection of such cells. Obviously, in the design, commercial considerations must have a material guidance on theoretical claims. Against the requirements for best theoretical conversion of kinetic energy must be matched the allowable limits of dimensions conformable with commercial possibilities, and in the interests of efficiency special attention must be paid to the arrangement and dimensions of the divergent channels or guide passages. As is well known, the form for guide passages is represented diagrammatically by Fig. 5, and this passage must be disposed in some form to lie conveniently in the desired casing. The general character will be either a simple outward flow type in one plane, Fig. 6, or a mixed type outward and axial in two planes, see Fig. 7 (*a* and *b*) and Fig. 8.

The divergent angle of guide vane, Fig. 5, for best efficiency was shown by Professor Gibson† to be 10 deg. to 11 deg. In many cases such a small divergent angle leads to a large overall diameter guide vane in order to give a sufficiently reduced speed of water to permit reversing its radial direction, and the result is a very heavy casing in consequence. For this reason divergent angles of 15 deg. are commonly found in practice. Evidently a more efficient pump will sometimes be heavier and more expensive than one less efficient, and commercial considerations must provide the final deciding factor between efficiency and weight. There is, of course, a school of design which believes in dealing with a proportion of the velocity conversion in the wheel itself, thus leaving less to be dealt with in the guide passage; the extent, however, to which this method can be used for weight saving is very small, if any.

The various assemblies of passages may clearly be grouped into:—

(A) Tangential and radial with return radial (see Fig. 6 and Fig. 1, *b*).

(B) Tangential and spiral (see Fig. 7 (*a* and *b*) and Fig. 8).‡

(C) Combinations (see Figs. 9, 10 and 11).

The Osborne Reynolds pump (1887 and 1875 type) employed an early form of the (B) assembly, and has adhered to this type up to the present day, various improvements being embodied from time to time, in some of which the author was concerned. On the Continent Messrs. Sulzer introduced, in 1886, design (A), and the author believes they have made little departure from the type beyond a considerable simplification of their early arrangement of passages, Fig. 2 *a* (page 509). Speaking generally, combination designs (C) are not so efficient as the simpler types (A) and (B), owing probably to the hydraulic loss through changing the radial direction of the water at high speed.

From a works construction point of view, "ring casings," Fig. 1 (*a* and *b*), are the most economical, and in practice give high efficiency. In the form similar to that shown in Fig. 12 the author some years ago was able to mould and cast ring casings without cores, machine moulding being adopted, and the cost per chamber coming out at a very low rate.

For "cylindrical" casings, Fig. 2 (*a* and *b*), a complete pattern is required for each size and variation in number of chambers. Its accessibility, however, and ease of dismantling is sometimes considered to be greater than with the "ring" type, though this is to a certain extent a matter of opinion. A great drawback to casings containing separate cells is that, on account of the sliding fit between the intermediate pieces and casing, an unknown amount of leakage constantly takes place between the cells. With a "ring" type of pump leakage is instantly detected and can be remedied. As a commercial proposition the author unhesitatingly favours

---

* Paper read before the Institution of Mechanical Engineers, May 18, 1917.

† "Mémoire sur les Turbines de M. Fourneyron," read at l'Academie des Sciences, August 6, 1838.

‡ "Récherches Théoriques et Experimentales sur les Roues a Réaction ou a Tuyaux," by M. Charles Combes, Paris, 1843, in which M. Combes refers to his own experiments and also to the turbines of several other makers and to the centrifugal pump of M. Demours, 1732.

§ Thomson whirl-chamber pump put down at Low Lodge Mill near Belfast in 1852. Another designed for land drainage in Jamaica in 1853 and made in Glasgow by Messrs. A. M'Onie and Co. Also a third built by James Ewing and Co., of Glasgow, for Demerara in 1858. See papers read before the Institution of Engineers in Scotland, vol. i, page 90, and "On a Centrifugal Pump with Exterior Whirlpool constructed for Draining Land," read October 27, 1858.

‖ "On the Flow of Water through Pipes and Passages having Converging or Diverging Boundaries," Proceedings, Roy. Soc. A., vol. lxxxiii, 1910, page 366, 1910. "On the Resistance to Rotation of Discs in Water at High Speeds," Proceedings, Inst.C.E., vol. clxxix, Session 1909–10, Part 1. "On the Resistance to Flow of Water through Pipes or Passages having Diverging Boundaries," Trans. Roy. Soc., Edinburgh, vol. xlviii, Part 1 (No. 5), 1911. "The Loss of Energy at Oblique Impact of Two Confined Streams of Water," Trans. Roy. Soc., Edinburgh, vol. xlviii, Part IV (No. 28), 1912. "The Design of Volute Chambers and of Guide Passages for Centrifugal Pumps," Proceedings, I.Mech.E., 1913, page 519.

* First patented—No. 724—1875. It is interesting to note that the drawing in this specification shows a pump which is practically Professor James Thomson's turbine reversed.

† Divergent angles have been most thoroughly investigated by Professor Gibson; see Proceedings, Roy. Soc. A., vol. lxxxiii, 1910, and Trans. Roy. Soc. of Edinburgh, vol. xlviii, Part 1, No. 5, 1911, &c.

‡ See Hopkinson and Chorlton Patent No. 8855—1904.

the divided or "ring" type of casing, and when properly carried out has met no difficulty with it in practice.

Before leaving this part of the subject a word about the finish of guide passage surfaces is necessary. For best efficiency the throat of the passage at least, if not the entire passage, should be gun-metal or bronze, as iron does not preserve a sufficiently good surface for high-velocity conditions. Common practice is to provide only three sides of the guide passage in bronze, Fig. 13, but this can only be defended on grounds of cheaper first cost. For best results a bronze plate should be provided to box-in the passage, the plate being attached to the guide-vane casting or dowelled to the casing. Guide vanes are sometimes cast completely boxed in, and this method necessitates hand-finishing of the passage by file and scraper; open vanes, however, lend themselves better to cleaning out and accurately finishing either by hand or by machining. A good smooth surface is essential for the best results and will always justify the increased cost.

The method adopted of securing guide vanes from rotation and vibration must be a thoroughly sound one or trouble will result.

II.—IMPELLERS.—Impellers are either:—

(1) Single entrant.

(2) Double entrant.

The first is almost universally in use for multicellular pumps, and the second almost exclusively for single-chamber pumps; it is only proposed to deal with the single entrant form.

Multicellular pumps use the single-eye wheel in three forms:—

(a) Unbalanced, unequal side areas, one rubbing shoulder, Fig. 14.

(b) Unbalanced, equal side areas, two rubbing shoulders Fig. 15*.

(c) Balanced—on paper, Figs. 16 and 17.

There are other types, mixed flow, radial and axial, &c., but these are not used to a sufficient extent to be worth including in this paper.

Type (a) may be said to be the one now generally used, that is, the preferable design.

Type (b) has certain advantages for machining, &c., but probably requires a stiffer shaft. Also, having no central supports, it tends to rotate the suction water of the next impeller and may be attended by greater stage leakage due to the increased annular running clearance.

Type (c) has the paper advantage of being in balance; actually it is a poor approximation to a balance. Disturbing factors are set up by: differences in side pressure on the impeller due to differences in volume and surface-form of the water contained on the two sides of the impeller, Fig. 18; differences of quantitative leakage through the two shoulders; and high-pressure leakage into one side of the impeller from the stage above, and leakage from the other side of the impeller to the next low-pressure stage below. Therefore, in practice, it is necessary to provide an additional end-balancing device of the hydraulic type, or a mechanically-positioning fitting such as a thrust collar or ball bearing; a method, especially for mine usage, not to be recommended.

The internal design of all impellers is governed by the same controlling features:—

(1) The entrance or inlet angle of vane,

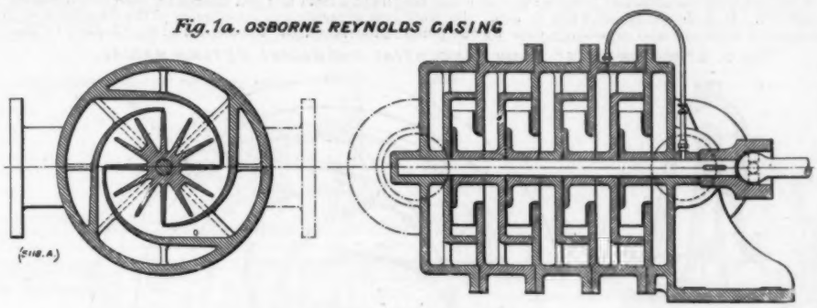
(2) The delivery or exit angle of vane.

The entire design must, while based on these considerations, consult the convenience of the workshop to the utmost degree possible without departing from required dimensional accuracy. The standing difficulty with turbine pumps, from the manufacturing point of view, is their constant variation to meet the infinite number of conditions of varying head, speed and quantity encountered in practice. Whatever efforts are made, it seems impossible to keep to a small number of standard impellers if the highest efficiency is to be reasonably well reached each time. Efficiency, it should be noted, is really the prime factor in design and not apparent first cost, for the pump is very often driven by an electric motor of greater value. If, therefore, by the use of a pump of higher efficiency, a reduction is effected in the necessary power and size of motor, the combination will generally come out cheaper.

The maker who elects to change his impellers and diffusers to suit the demands of the inquiries as they come in will obtain a higher percentage of orders than one who has standardised his, even though the latter may have

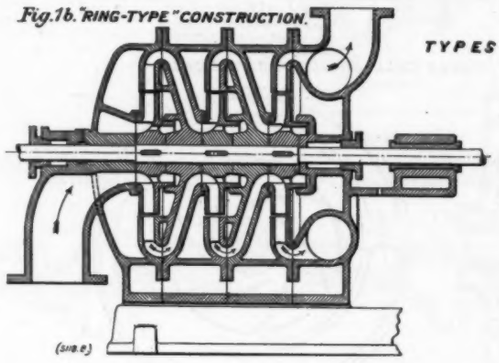
* See also Hopkinson and Chorlton Patent No. 8855—1904.

Fig. 1a. OSBORNE REYNOLDS CASING



(SIR. A.)

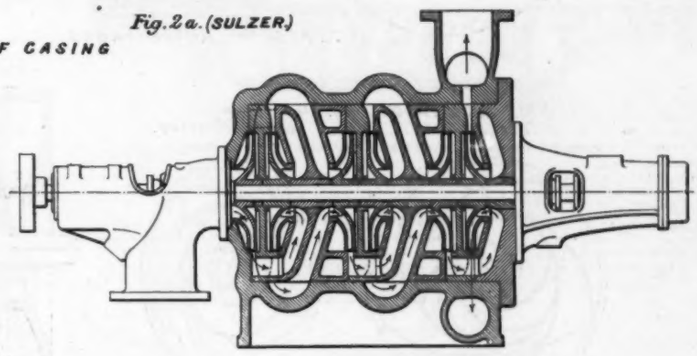
Fig. 1b. "RING-TYPE" CONSTRUCTION.



(SIR. E.)

TYPES OF CASING

Fig. 2a. (SULZER.)



TYPES OF CASING

Fig. 4. COMBINATION OF "CYLINDRICAL AND "RING" FEATURES.

Fig. 2b. CONTINENTAL PUMP. "CYLINDRICAL-CASING" CONSTRUCTION.

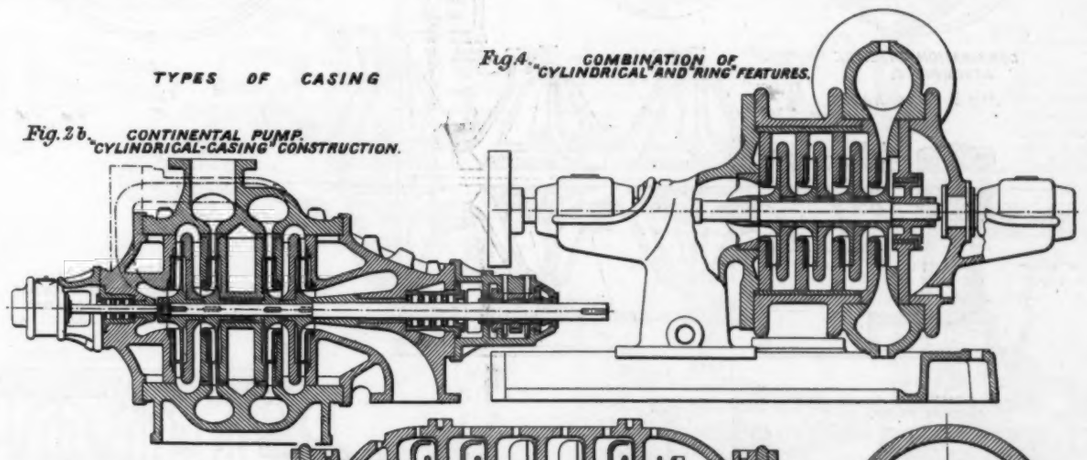
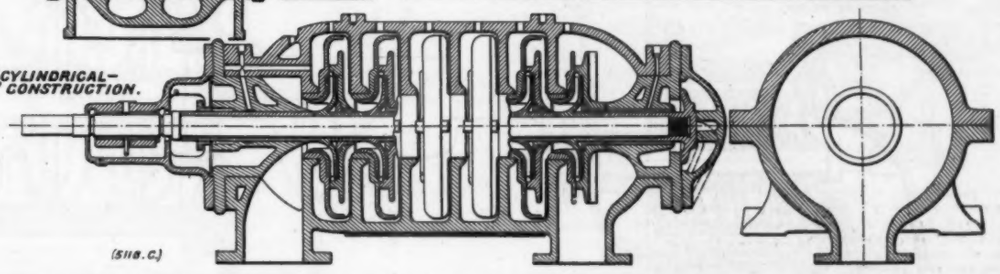


Fig. 3. SPLIT "CYLINDRICAL-CASING" CONSTRUCTION.



(SIR. C.)

reduced costs by making in large quantity. In considering if in any way it is possible to meet the designer's requirements without losing all the advantages of repetition manufacture, we may first take the inlet angle. This depends on the resultant of the (supposed) radial flow of the entering water and the peripheral speed of the inlet tip itself, and it usually varies between 15 deg. and 30 deg. If we elect always to use 15 deg. we might suffer in some cases to the extent of 3 per cent. or 4 per cent. If we take two sizes, 15 deg. and 25 deg., and make a liberal provision of inlet width, or, as some designers phrase it, make an adequate allowance for "weir coefficient" at entrance, we shall only drop perhaps 1 per cent. in exceptional cases; so it seems possible to do something in the way of standardising the inlet angle.

One might refer, in passing, to some of the current ideas concerning the inlet angle and the condition of the water at entry to the impeller. Some designers have maintained that very great accuracy of the inlet angle is vital to high efficiency, in spite of the fact that in the ordinary unobstructed eye it is impossible to say what the absolute velocity and direction of the incoming water is, and therefore to estimate precisely what the correct inlet angle should be is impossible. Further, the behaviour of the incoming water varies with every rate of flow, and the only way to foretell its condition would be to insert inlet guide vanes; this, however, in such experiments as the author is aware of, has proved an objectionable practice and only introduces further losses in the pump. Another school holds that it is an advantage purposely to introduce a forward whirl in the water at the eye with the object of helping the water into the impeller. If such an initial whirl is used, the work necessary to create it is necessarily done by the pump itself, and it is therefore questionable if this does not entirely overweigh any possible gain.

The discharge angle depends on the resultant of the peripheral speed of the wheel and the radial outflow, the variation of which is so great it seems impossible to devise any standardisation. To meet quantity variation two widths of impeller may be used, and to meet required speeds of revolution it is usual to allow a small percentage variation in the impeller diameter to suit special demands; this latter, however, is conveniently done without pattern or casting alterations.

The foregoing considerations lead to the conclusion that nothing less than a special core-box will be required for each case, and it is quite usual to meet the difficulty in this way. Evidently, however, a most valuable appliance would be a special form of core-box which in itself was more of a standard and could be adopted for manufacture in quantity; this result might be effected by fitting in vanes of a flexible nature, so that the necessary alteration and adjustment would not be great, and the whole outfit would come out cheaper than if a pattern-maker had to build a fresh box and fittings for each new demand. As the accuracy and smoothness of the impeller is of great importance, the author has always looked to machine moulding, and to a special machine like a wheel-moulding machine, for the purpose; he has not, however, as yet, arrived at the final design for such.

The surfaces of the impeller, both inside and out, play an important part in the efficiency of a turbine pump. The smoother the outside surface the less the power lost in disc friction, and the less the power wasted in revolving idle "dead water."* An interesting point to note is that the greater the speed of revolution of the "dead water" (that is, the greater the power absorbed in this

*See Professor Gibson's disc friction experiments, already referred to.

Fig. 5. FORM OF GUIDE PASSAGE. THROAT ONLY

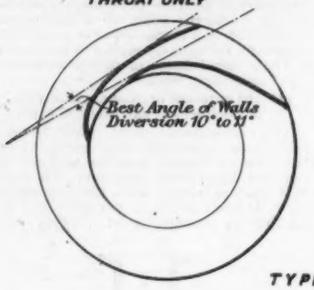
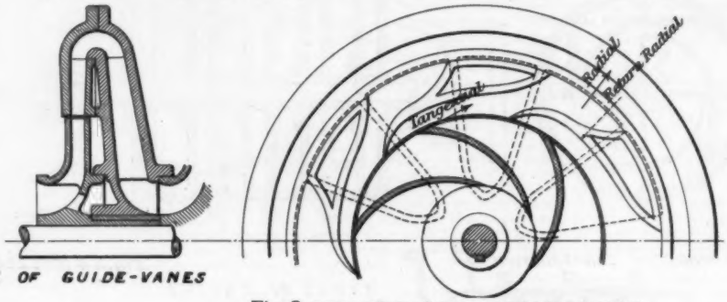


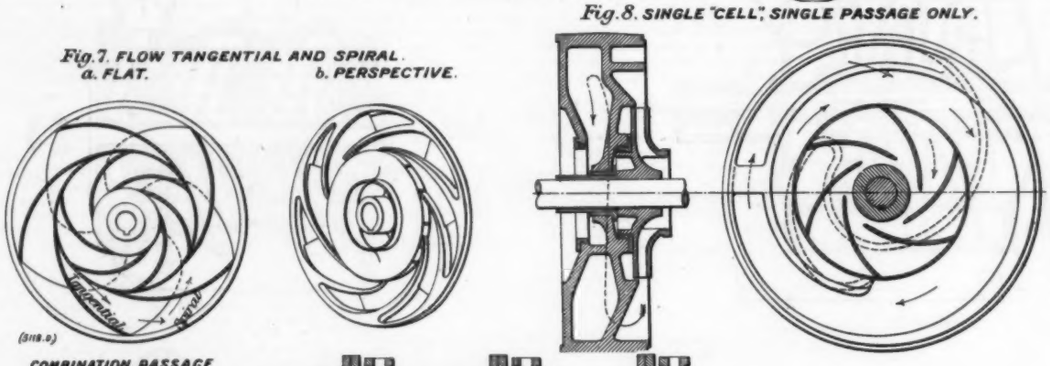
Fig. 6. "STAGE" OR "CELL." FLOW TANGENTIAL AND RADIAL, RETURN RADIAL.



TYPES OF GUIDE-VANES

Fig. 8. SINGLE "CELL", SINGLE PASSAGE ONLY.

Fig. 7. FLOW TANGENTIAL AND SPIRAL.
a. FLAT. b. PERSPECTIVE.



COMBINATION PASSAGE ASSEMBLIES.

Fig. 9. (MARCHAND)

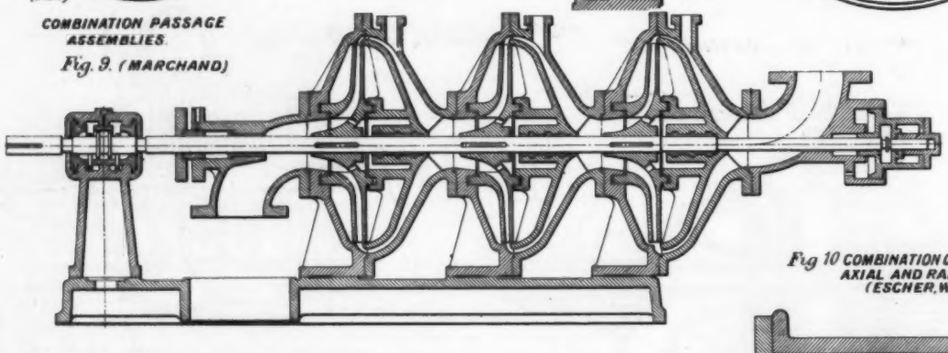
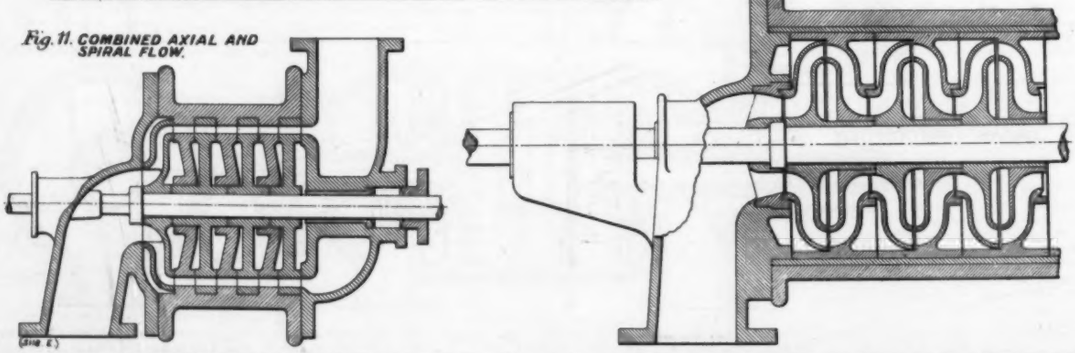


Fig. 10 COMBINATION OF TANGENTIAL AXIAL AND RADIAL FLOW (ESCHER, WYSS.)

Fig. 11. COMBINED AXIAL AND SPIRAL FLOW.



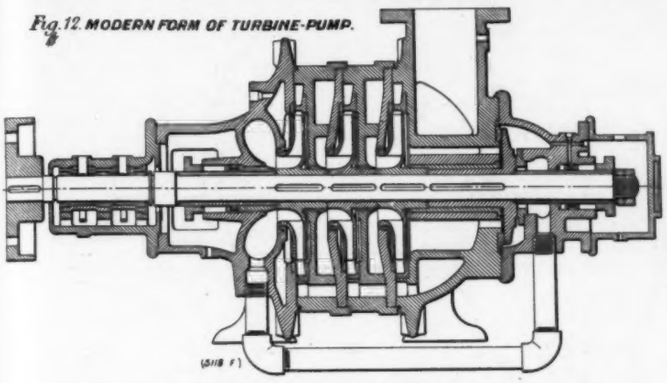
way), the less the leakage from the periphery of the impeller; but a little consideration will show that greater overall economy is gained by reducing the wasted power in idle revolution to a minimum. As regards the internal smoothness of the passages of the impeller, it is usual practice to clean up the surfaces as well as possible with file and scraper. Impellers have been built up with one loose side, so as to permit of machining or more effectively cleaning the interior; and it is evident that with individual impellers producing high heads the results would well repay the extra cost. Objections to this practice are the difficulty of making attachment of the two parts and the extra weight necessary to provide attachments.

III. BALANCING APPLIANCE.—The experienced designer knows, from practical knowledge, that even if a group of impellers, or even a single impeller, is theoretically balanced by equivalent areas subject to pressure, it will not in actual practice be free from all end-thrust. Apart from variable leakage at the two sides of an impeller, which, by the way, is the principal cause of end thrust, we often have variable side surface both of the impeller and the cell chamber. If the conditions of capacity or surface of the two clearance-chambers vary, the resulting pressures will vary and an axial thrust is set up. Professor Gibson has investigated the effects on efficiency (power lost) due to varying the side clearance of the impeller, and he took readings of circumferential pressure due to that leakage. It can readily be seen, therefore, that the effect of the chamber at one side of a wheel having greater capacity than the other, or having more obstructions in the way of ribs, pockets or exceptional roughness, &c., plays some part in the determination of end-thrust.

All the earlier turbine pumps employed some form of thrust bearing, either of the collar or the ball type, to keep the impellers in correct alignment with the guide passages, and it was not until much trouble had been experienced with these that hydraulic control was ultimately adopted. Experience showed that much higher end pressures were set up than were ever anticipated, but for a period mechanical devices were persisted in, improvements being made attempting to withstand the excessive loads, and scant notice, it would appear, being taken of water turbine practice, where for many years it had been the custom to relieve axial thrust hydraulically. Fig. 19 illustrates an hydraulic balancing device* in use on Francis turbines, and which, if properly proportioned, is automatic, and thus embodies all the essential points of many present tur bine pump balancers. One should bear in mind that the relation between the calculable axial thrust and the thrust realised in a water turbine is much closer than in a centrifugal pump of the multi-stage type, the reason of this being that the disturbing factor in a high-lift pump is the leakage from stage to stage.

The well-known application of turbine pumps to high lifts by Messrs. Sulzer at the Horcajo Mines in 1898 was carried out with back-to-back impellers, and a ball thrust bearing was provided to take the end-thrust (in one direction only), which is inseparable from this arrangement of impellers. In 1901 Professor Rateau was manufacturing pumps with end-thrust approximately eliminated hydraulically by his well-known method of shroud reduction, and provided with a balancing piston, Fig. 20.† This method was not automatic, and the pressure on the piston could only be adjusted by means of a hand-operated throttle valve. However, this was the first step, and the automatic control of the necessary pressure on the balancing device and determined by the end movement of the spindle followed as a matter of course. The development of the differential type of balancer, carried out under the author's direction in 1913,‡ extended over several years, progressing step by step from a hand-adjusted needle valve, Fig. 21,

Fig. 12. MODERN FORM OF TURBINE-PUMP.



IMPELLERS, UNBALANCED.

Fig. 13. (FARCOT.)

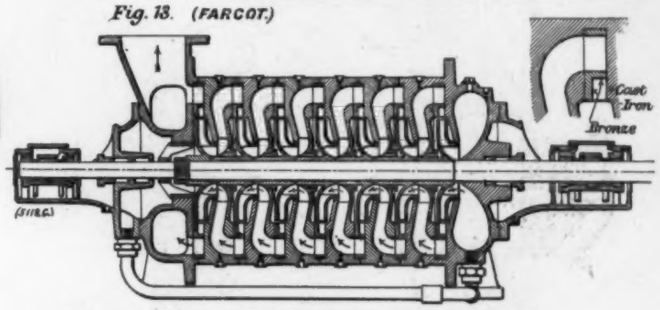


Fig. 14. UNEQUAL SIDE AREA. ONE RUBBING SHOULDER.

Fig. 15. EQUAL SIDE AREAS. TWO RUBBING SHOULDERS.

IMPELLERS, BALANCED.

Fig. 16.

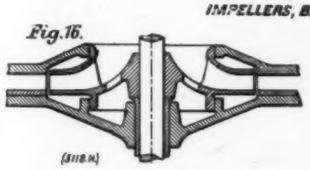


Fig. 17.

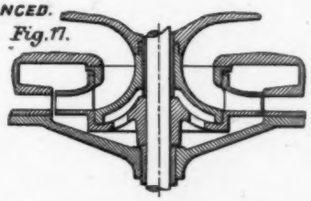


Fig. 18. EFFECTS OF GYRATORY PRESSURES ON END THRUST.

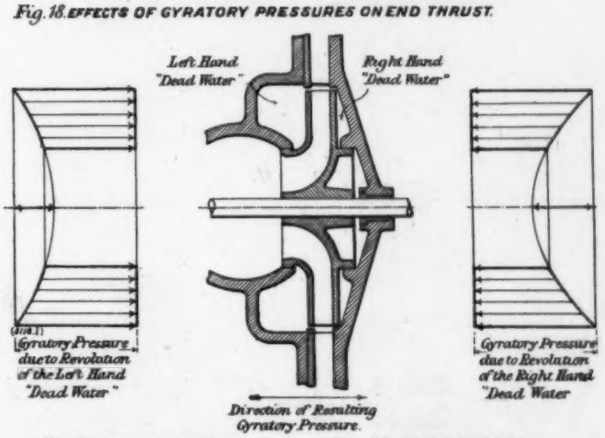

Left Hand "Dead Water"
Right Hand "Dead Water"
Gyratory Pressure due to Revolution of the Left Hand "Dead Water"
Gyratory Pressure due to Revolution of the Right Hand "Dead Water"
Direction of Resulting Gyratory Pressure.

Fig. 19. HYDRAULIC AXIAL BALANCING DEVICE (FRANCIS)

Fig. 20. PUMP (RATEAU) SHOWING HYDRAULIC COMPENSATOR.

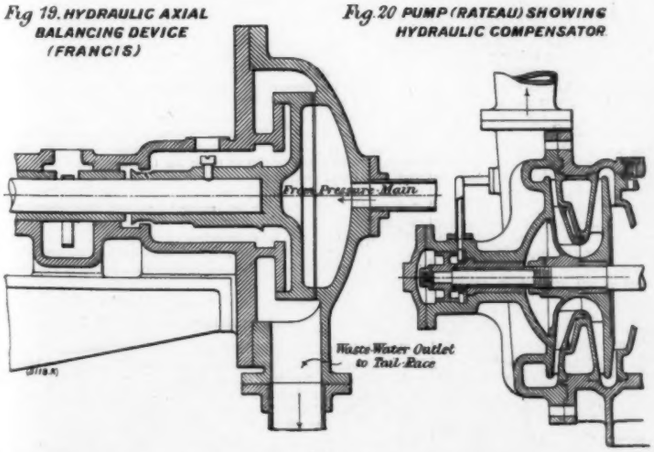
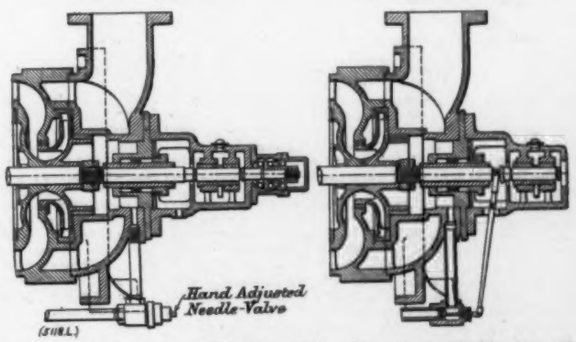


Fig. 21. HAND-ADJUSTED BALANCER.

Fig. 22. MECHANICALLY ADJUSTED BALANCER.



* Am. Soc. Mech. Engineers, September, 1915.

* Proceedings, Inst.C.E. 1909, vol. clxxvi, page 317.

† Bulletin de la Société d'Encouragement pour l'Industrie Nationale (Paris), December 31, 1901, page 729, and British Patent No. 18,106—1901.

‡ ENGINEERING, August 22, 1913.

regulated to produce the required balancing pressure, to a mechanically operated needle valve, Fig. 22, actuated by the axial movement of the spindle, and then through several forms of rotating throttle valve disposed on the spindle itself and actuated by the same means. Further reference to the final balancing appliance (diagrammatically shown in Fig. 23) will be made shortly.

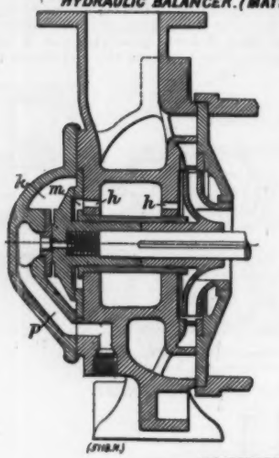
In 1906 Messrs. Sulzer brought out their device for relieving thrust shown in Fig. 24, and the principle used has been followed by many other makers and introduced with many variations. The action of the Sulzer device led the author to devise form "b," or the double-action control with which such difficulties are overcome.

Fig. 23 (also in Fig. 12) finally shows the present standard double-plate or compound differential balance arrangement. The balance piston and regulating valve are combined, and form a balance disc with two active throttling surfaces floating between two fixed seatings with a minimum clearance. All the working faces are arranged vertically so as to be independent of possible vibrations of the rotary system. The pressure water, escaping from the rim of the last impeller, passes

silicon or a nickel steel, seems to best fit the requirements. Non-metallic substances, such as red fibre, woodite or dexine, have been considered, but any material which becomes slightly absorbent after long immersion is useless.

Sometimes difficulty is experienced in starting up large turbine pumps on account of the large diameter balance rings being held together in metallic contact instead of being apart in their usual running position; the result is an abnormally high starting torque for the motor and probable damage to the faces of the balancing device.

Fig. 23. DIFFERENTIAL HYDRAULIC BALANCER. (MATHER & PLATT.)



SINGLE-PLATE BALANCERS.

Fig. 24. SINGLE-PLATE BALANCER. (SULZER).

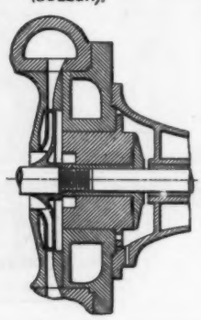


Fig. 25. (MILLINGTON.)

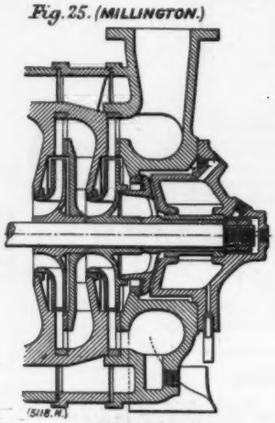
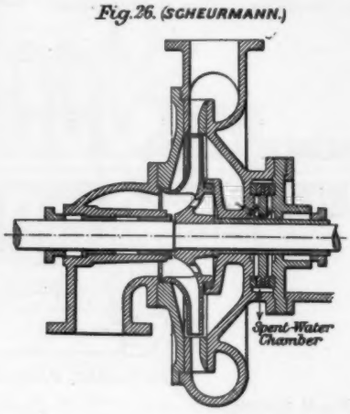


Fig. 26. (SCHEURMANN.)



CONTINENTAL HYDRAULIC BALANCERS.

Fig. 27. DIFFERENTIAL.

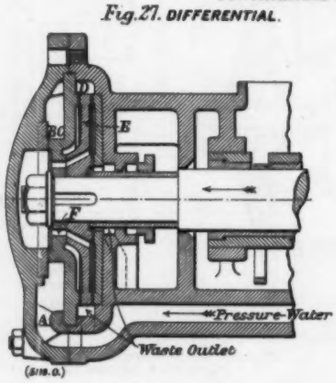


Fig. 28. SINGLE-PLATE.

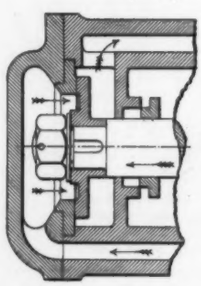
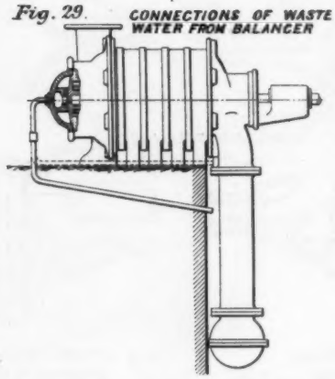


Fig. 29. CONNECTIONS OF WASTE WATER FROM BALANCER



is simple; it comprises a single plate with a throttling device, through which the pressure water has access to the plate. The area of the plate is sufficient when acted on by a somewhat throttled delivery pressure to overcome the tendency of the rotor to travel in the opposite direction. As the pressure gradually rises before the plate, its increased power carries the rotor to the right until further motion is arrested by the escape of the increased pressure through a widening annular space between the plate and its facing seat. An ultimate running position is reached when the leakage through the clearance between valve and seat is sufficient to maintain a pressure at the back of the plate equal to the set of the rotor in the opposite direction. It will be seen that the balance is quite automatic in its control, end movement in either direction taking place until stability is reached.

Without going further into the detailed evolution of automatic control of the hydraulic end-balance of the turbine, it is sufficient to say that the devices adopted resolve themselves into two basic forms:—

(a) Single-acting (simple), of which the Sulzer, Fig. 24, is the general type.

(b) Double-acting (differential), of which Fig. 23 is the type, and Fig. 13 a modification.

Other single-plate forms are shown in Figs. 25 and 26. In the first of these the throttling agent, a small nipple, is removed to the discharge side of the plate, thus giving, in a measure, a double action to the plate; the quick action and limited travel due to the second face of the differential type is not obtained, however, and there is a possible disadvantage in the small aperture when dealing with impure water. The second example combines some of the points of both forms of balancer, but as the pressure in the spent-water chamber is always augmented by high-pressure leakage into the low-pressure side of the plate, the device is, obviously, relatively extravagant in leakage water, and must therefore be considered inefficient.

The general effect of wear on single-plate balancers is increased leakage, the outcome of which is further end-movement in one direction until finally the impeller discharges do not match their guide-vane entrances but become off-set. This tendency in hydraulic balancers through the holes *h* into the pressure chamber *m*, from which it escapes along the throttling surface of the balance valve into the regulating pressure chamber *k*, and from there past the small throttling surface into the escape pipe *p*, leading preferably to an open drain, or back into the suction chamber of the pump. The double-plate balance appears to be the most sensitive automatic balancing device in practical use, for, by it, closing up of the plate on the large throttling face causes an opening out on the small one, thus multiplying the balancing effect; a movement of a thousandth part, or so, of an inch being all that is required to counterbalance the most extreme and sudden changes of the hydraulic equilibrium of the pump. The other and most important feature of this auto-plate balance is that it always maintains the central position of the impellers, even if the throttling surfaces become worn, as is invariably the case when pumps are working on gritty water.

A continental form arising out of this type is shown in Fig. 27, and it is obvious that the same remarks concerning extravagance in leakage water apply to this example as to Fig. 26 (above). The arrangement of the balancer at the end of the spindle outside the external bearings is not a good one, for the reason that a high-pressure gland at the delivery end of the pump is still required, and an additional gland also for the balancer-housing.

A single-plate balance made by the same firm as the above is shown in Fig. 28, and this too is open to the same objection as regards disposition on the spindle.

It is usual to make hydraulic balancers with renewable faces at the points of close running, so that the appliance can be readily repaired after wear has taken place. As regards the best material to be used for the renewable part, some considerable experience is needed before a decision can be made. Gun-metal was probably the first material to be used, but cast iron, cast steel and hard bronze have all been tried, the present practice usually being to fit hard bronze. The ideal material is one which is hard and "short," and has a very low coefficient of friction when working in water; a material which "drags" is quite unsuitable, and apparently an incorrodible iron, one containing a high percentage of

When a turbine pump with differential balancer is "stopped," the rotor will always take up a position with the balancing faces apart if the waste-water outlet, Fig. 29 (above), is taken to an open drain; however, if the spent water is led back to the suction pipe of the pump and a foot valve is provided at the end of the suction pipe, the whole rotor is forced towards the suction end of the pump as soon as the foot valve closes and the head pressure comes on. The reason for this is that the area of the balancer on the outlet side is greater than on the inlet side by an amount equal to the diameter of the spindle. For this reason the waste water from a balancer should not be connected to the suction pipe of a pump, or means should be taken in the pump to equalise the areas subject to the static hydraulic pressure, Fig. 12.

(To be continued.)

THE "COMBINATION" RUSSIAN READY RECKONER.—We have received a copy of a pamphlet having the above title, prepared by Mr. C. T. Evenette, C.E., and issued at the price of 1*s.* 3*d.* by Messrs. J. Halden and Co., Limited, Manchester and London. It gives the equivalent of Russian-English and English-Russian, Russian-metric and metric-Russian, lineal, square, cubic, troy, avoirdupois, liquid and dry measures.

ELECTRIFICATION OF THE D.R. COTTON MILLS, ROCHDALE.—Electricity has been exclusively adopted for lighting and driving these mills, there being an aggregate of 2,500 h.p. of Witton motors and approximately 1,360 Osram lamps with an average candle power of 40. Electric power is derived from the mains of the Rochdale Corporation at a pressure of 6,000 volts, three-phase, being transformed down and distributed throughout the works at a pressure of 400 volts for power and 200 for lighting. The motors installed vary in size from 150 h.p. downwards. The electrical plant, lamps, cables, &c., were supplied by the General Electric Company, Limited, Witton, Birmingham.